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THE

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[FOURTH SERIES.]

ART. X.—*The Jurassic Formation on the Atlantic Coast.—Supplement;** by O. C. MARSH.

AT the autumn meeting of the National Academy last year, in New York, I made a communication entitled "The Jurassic Formation on the Atlantic Coast."† In this paper I brought together the results of a careful investigation which I had been conducting for several years, going to prove that the Jurassic formation, generally supposed to be wanting on the Atlantic border, was represented by a definite series of strata in the exact position where such deposits were to be expected. Accompanying this communication, I exhibited a number of drawings and sections illustrating the Jurassic deposits of the West, which I had long before investigated and fully described; namely, the Baptanodon beds, consisting of marine Jurassic strata with many characteristic fossils, mostly invertebrates, and above these the fresh-water Atlantosaurus beds, which have yielded such vast numbers of gigantic reptiles and other characteristic vertebrates. Sections showing the relative position of these deposits, with the strata above and below them as they are seen at several localities in Wyoming and Colorado, were also exhibited.

In comparison with this great development of the Jurassic in the West, I next discussed the so-called Potomac formation in Maryland, in which I had found a corresponding vertebrate fauna that proved the strata containing them to be also of Jurassic age. I then gave a brief account of my researches

* Abstract of communication made to the National Academy of Sciences, Boston meeting, November 18, 1897.

† This Journal, vol. ii, p. 433, December, 1896; and Science, vol. iv, p. 805, December 4, 1896. See also, this Journal, vol. ii, p. 295, October, and p. 375, November, 1896.

during that season, in following essentially the same strata to the eastward through Delaware and New Jersey, and likewise presented evidence showing that apparently the same Jurassic beds were to be found in position beneath Long Island, Block Island, and Martha's Vineyard, represented by the variegated basal clays of these islands, which had previously been supposed to be of much later age. The evidence seemed conclusive that in this series we had remnants of an extensive formation of fresh-water origin, the strata consisting mainly of soft sandstones and plastic clays of great thickness. In their physical characters, and especially in their variegated brilliant colors, these deposits differed widely from any others known on the Atlantic border, and were only equalled in this respect by the Jurassic beds of the Rocky Mountain region. The presence on the Atlantic coast of such an extensive formation, with its massive beds of plastic clay, all of fresh-water origin, clearly proved the former existence of a great barrier between the basin in which these clays were deposited and the Atlantic Ocean, a barrier that has long since disappeared through subsidence, or was broken down by the waves of the Atlantic, which are still rapidly removing the remnants of the formation along its eastern exposure, as may be seen on Block Island, and at Gay Head on Martha's Vineyard.

In discussing the age of this formation, its position above the Triassic and below the marine Cretaceous, its characteristic physical characters, distinct from those above and below, and its western extension into the strata of undoubted Jurassic age in the Potomac beds of Maryland, all pointed to the conclusion that its members belong to the same general epoch, and were deposited during Jurassic time.

In the paper thus cited, I confined myself strictly to the Potomac formation north of the Potomac River, and what I believed to be its eastern extension as far as Martha's Vineyard, all of which I had personally explored. I particularly avoided any discussion of the so-called Potomac beds south of the Potomac River, although I had been over these deposits at various points along the Atlantic border and around the Gulf as far as the Mississippi River. I closed the paper with the promise of taking up that part of the subject later.

As the question was a difficult one and still under investigation, I likewise guarded myself against expressing the opinion that all the so-called Potomac deposits were Jurassic. My words on this point were as follows:

"It cannot, of course, be positively asserted at present that the entire series now known as Potomac is all Jurassic, or represents the whole Jurassic. The Lias appears to be wanting, and some of the upper strata may possibly prove to belong to the Dakota."*

* This Journal, vol. ii, p. 436, 1896.

The Dakota Sandstone.

In regard to the sandstone known as Dakota, and generally considered of Cretaceous age, I also spoke cautiously, as behooves anyone who has seen this formation at many of its outcrops over a wide range of territory in the West, where its physical characters are striking, and its fossil remains are mainly detached leaves of plants.

In figure 1 of my paper, showing geological horizons and designed especially to represent the succession of vertebrate life in the West during Mesozoic and Cenozoic time, and so defined in the text, I left a blank space above the Jurassic for the Dakota, exactly where I had found a sandstone, regarded as Dakota, in place at many widely separated localities. I said little about the Dakota itself, as I did not wish then to raise questions outside the scope of my paper.

Had the occasion been appropriate, I might have said that the group termed Dakota in my section, I consider as more extensive than the single series of sandstones defined as Dakota by Meek and Hayden in 1861. The original locality of this sandstone was the bluffs near the Missouri River in Dakota County, Nebraska, and these authors included with this the supposed southern extension of the sandstone in eastern Kansas. This placed the Dakota on the eastern margin of the great Cretaceous basin which extended westward to the Rocky Mountains. The attempt of Meek and Hayden to identify the Dakota further north, near the mouth of the Judith River, is now known to have failed, but the name transferred to certain sandstones along the flanks of the Rocky Mountains has been accepted, and this term has long been in use for these strata from Canada to Mexico. With this so-called Dakota sandstone, however, have been included other deposits, the upper part of which may be Cretaceous, while the rest I regard as Jurassic, and with good reason. These intermediate beds may be seen at various places, especially around the border of the Black Hills and along the eastern flanks of the Rocky Mountains in Colorado. As I shall refer to this point later in the present communication, I will not discuss it here.

Opinions of Various Geologists.

The paper I have now cited, I regarded as the preliminary statement of an important case, and not its final demonstration. When presented to the Academy, it received the general approval of the members interested in the subject, and one of them, the late Professor Cope, who was best qualified to weigh the evidence of paleontology, fully endorsed my conclusions, and added that he himself had long suspected that the strata under discussion would prove to be of Jurassic age.

When an abstract of my communication was published, although without the main illustrations shown to the Academy, I received further endorsement from geologists familiar with the subject, but from others, marks of disapproval predominated. This I had anticipated in a measure, especially from the paleobotanists, whom I believed responsible for much of the confusion that had so long delayed the solution of similar questions, East and West. This point I brought out in my paper, but in an impersonal manner that I hoped would offend none of the craft.

The prompt and vigorous rejoinders that even my first informal announcement drew from two paleobotanists, A. Hollick and L. F. Ward,* showed that I had trespassed upon their bailiwick, and that some of the questions raised they had settled to their own satisfaction. As their ideas in regard to the value of fragmentary fossil plants as evidence of geologic age differed so widely from my own and from those of many paleontologists, no specific reply on my part seemed necessary, and I have none to make now. Professor Ward has admitted that the plants found with the vertebrates in the Potomac beds of Maryland may be Jurassic, and that removes one of the main points at issue between us. His words are as follows:

> "If the stratigraphical relations and the animal remains shall finally require its reference to the Jurassic, the plants do not present any serious obstacle to such reference." (Loc. cit., p. 759.)

That the more eastern beds may represent a somewhat higher horizon, I can readily believe, but I must doubt the evidence that would separate so characteristic and homogeneous a series of sands and plastic clays into two sections, one Cretaceous and the other Jurassic. The few imperfect plant remains that we are told authorize this separation must be reinforced by other testimony to obtain even the support of probability, especially when paleobotanists differ so widely among themselves as to the real significance of the fragmentary remains they describe.

Next in order among my reviewers was R. T. Hill,† well known for his researches in the geology of Texas, but apparently not familiar with the typical Jurassic, East or West. He evidently had not read my paper carefully, though he criticises it at length, mainly to confirm his own conclusions as to the Cretaceous age of certain deposits in Texas, which he seems to imagine I do not endorse. As I especially avoided expressing any opinion on that point, or in regard to the Dakota being the base of the Cretaceous in this country, as I have already stated, no reply at present seems called for on my part, although I hope later to refer to the question he raises about the age of the so-called southern Potomac.

* Science, vol. iv, p. 571, and p. 757, 1896.
† The same volume, p. 918, 1896.

I took it for granted, in my paper cited, that American geologists who were not familiar personally with the great development of the Jurassic formation in Europe, or who had had no opportunity of examining typical sections of this formation in western America, or of seeing its deposits in place full of characteristic fossils and extending hundreds of miles in half a dozen states, were at least sufficiently acquainted with the literature of the last twenty years to know that two of the best-marked Jurassic horizons in any part of the world existed in this country.

Although my communication, as printed, was in fairly clear English, I find it was misunderstood in various other points, as subsequent reviews soon showed. If these marks of disapproval had been recorded by fireside geologists, who so often differ with those who furnish facts, I should have followed my usual rule and made no reply. They were, however, mainly written by field geologists who had seen something of the West, and ought evidently to have seen more, for the facts I stated can be readily verified at any of the localities mentioned and at many others. The failure to do so well illustrates a law of human nature; namely, that men see what they have eyes to see. The West is an extensive country. The plant men who go there seem to see only fossil plants; the invertebrate collectors notice only their own favorites, and as both classes are numerous, the extinct vertebrates are too often overlooked or only peculiar and striking specimens secured. Thus the most valuable evidence as to the age of strata is neglected, and the decision rendered has so frequently to be reversed. This neglect is not confined to field work alone, where fossil vertebrates should be found, but too often extends to the literature of the subject.

Let me illustrate this by a short quotation from a well-known work:

"The Jurassic system, which is so largely developed in Europe, containing the remains of huge swimming and flying reptiles * * is but sparingly represented in American geology, and none of the gigantic vertebrates have as yet been found here."*

The above extract may fairly be taken as representing the information on the subject known to the authors, or at least to the editor, when this work was published. It is, moreover, a fair sample of much that has since been written about the Jurassic formation of this country and its fossil contents, especially by those not familiar with this subject, but whose work in allied fields should at least have made them acquainted with the main results of our vertebrate paleontology, which had become a part of the world's scientific knowledge.

* Geology of the Black Hills, by Newton and Jenney; edited by G. K. Gilbert; p. 151, 1880.

For example, at the time the above work was published, one of the most fruitful horizons of vertebrate fossils ever discovered had been known for several years in the Jurassic of the West. Many tons of gigantic fossil vertebrates had been collected from several localities, and the principal forms described and figured, while the illustrations had been reproduced even in text-books. Moreover, the Jurassic horizon in which these and other remains were found had been definitely determined and named the Atlantosaurus beds, and a geological section showing their position and characteristic genera had been published several times. The fossils thus discovered embraced mammals, birds, reptiles, and fishes, nearly all of well-marked Jurassic types.

Since 1880, when the statement I have quoted was made, other discoveries have followed in rapid succession, and the Jurassic vertebrate fauna of the West is now known to be a most rich and varied one, far in advance of that from any other part of the world. More than one hundred and fifty species of extinct vertebrates, some of them represented by hundreds of specimens, have been brought to light, and over one hundred of these have already been described, and the more important have been refigured and republished in various parts of the world, including text-books, so that anyone with even an elementary knowledge of the subject can see that they are Jurassic in type. Nevertheless, a number of American geologists whose studies have kept them in other fields still appear to be ignorant of nearly all that has been made known about vertebrate paleontology in this country during the last quarter of a century, and seem to think that the Jurassic formation here is of small importance, and that its area should be restricted rather than enlarged.

Another of my reviewers was G. K. Gilbert, editor of the work from which I have just quoted. Whether he intended his remarks on my paper to be taken seriously is not clear. Apparently he wished to start an academic discussion on correlation, and under the circumstances this would probably have led from the Rocky Mountains to the Mountains of the Moon, one of his latest fields of investigation. If he is really in doubt about the methods of correlation of vertebrate fossils, he can perhaps find the information he needs in text-books.

First of all, however, I must question the accuracy of some of the statements in his review of my paper. One of these is as follows:

"Through a comparison of vertebrates from the Potomac formation with vertebrates from other formations he has inferred the Jurassic age of the Potomac; but he gives no hint of the character of his evidence or the course of his reasoning."*

* Science, vol. iv, p. 876, 1896.

Had this critic read the whole of my paper, he would have found the following statement bearing on this point:

"The Jurassic age of the Atlantosaurus beds of the West has now been demonstrated beyond question by the presence of a rich fauna of mammals, birds, reptiles, and fishes. Among these, the *Sauropoda* were dominant, and the other Dinosaurs well represented.

'In the Potomac beds of Maryland, the same Jurassic vertebrate fauna is present, as shown by the remains of five different orders of reptiles already discovered in them. Among the Dinosaurs are the *Sauropoda*, the *Theropoda*, and the *Predentata*, the first group represented by several genera and a great number of individuals. One of these genera is *Pleurocœlus*, which has also been found in the Jurassic of the West. Besides the Dinosaurs, characteristic remains of *Crocodilia* and *Testudinata* are not uncommon, and various Fishes have been found. The remains of these six groups already known are amply sufficient to determine the age of the formation, and still more important discoveries doubtless await careful exploration."*

Mr. Gilbert's next statement, which is likewise without real foundation, is as follows:

"The conclusion that the Atlantosaurus and other horizons of the Rocky Mountain region are Jurassic was announced in the same way, without citation of evidence."

The announcement of the Atlantosaurus beds as Jurassic was accompanied by a section showing their exact position in the geological scale, and the characteristic genera of Reptilia which then indicated their Jurassic age.† This was followed by descriptions in rapid succession of many other vertebrate fossils, proving beyond question that the horizon was Jurassic. The Baptanodon beds were also defined, and their position in the geological series established by characteristic fossils. The demonstration on this point, I have already given above, and need not repeat here.

Another point needs correction, as Mr. Gilbert evidently consulted my recent classification of the *Dinosauria*‡ without appreciating the evidence it contained. This is shown by the following quotation from his review:

"The closest affinity of the European and American formations seems to be expressed by the statement that there is one American genus which falls in the same family with a European genus."

* This Journal, vol. ii, p. 445, 1896.

† Proceedings American Association, Nashville meeting, p. 220, 1878; see also Popular Science Monthly, p. 520, March, 1878.

‡ The Dinosaurs of North America, 16th Annual Report, U. S. Geological Survey, p. 238, 1896.

The genera named in my recent classification were mainly typical forms, and I had no intention of making a complete catalogue of all the known genera, as anyone familiar with the subject could readily see. By way of further instruction, let me repeat here what I have recently said about one of these typical forms.

"*Pleurocœlus* is one of the most characteristic genera of the Sauropodous *Dinosauria*, and its value in marking a geological horizon should therefore have considerable weight. It is now known from the two European localities mentioned above, both in strata of undoubted Jurassic age. The same genus is well represented in the Potomac deposits of Maryland, and has been found, also, in the Atlantosaurus beds of Wyoming, thus offering, with the associated fossils, strong testimony that the American and European localities are in the same general horizon of the upper Jurassic."*

Had Mr. Gilbert been familiar with the subject discussed in his review, he would have known that, so far as present evidence goes, there are other genera of Dinosaurs common to Europe and America, found in apparently the same Jurassic horizon, and that this is true also of various other reptiles and of fishes. More important still is the correspondence between the genera of Jurassic mammals of the two continents, which in itself is sufficient to demonstrate that they belong in essentially the same horizon.

The last point Mr. Gilbert raises in his review is a geological one, and even here he has missed the mark. His words are as follows:

"The physical relations of the beds afford a presumption in favor of their Cretaceous age. Prof. Marsh mentions that the Potomac formation in New Jersey passes by insensible gradation into marine Cretaceous above."

The two statements in this quotation are, in my opinion, both erroneous, and the second is contrary to the idea I intended to convey. The physical relations of the beds in question are in favor of their Jurassic age, and the Potomac strata do not pass by insensible gradation into the marine Cretaceous above. Although the two are apparently conformable, the passage from one to the other was a change from fresh-water to marine deposits, which in itself implies a break that may represent a long period of time, perhaps the entire lower Cretaceous. This break was clearly indicated in the geological section that I gave in my paper (figure 2), and to make this point clear, the same section is here repeated.

* This Journal, vol. iv, p. 415, December, 1897.

This typical section represents the successive Mesozoic and more recent formations, from New Brunswick, New Jersey, on a line southeast, through Lower Squankum to the Atlantic. The distance indicated is about forty miles.

Geological Section in New Jersey.

a, Triassic; *b*, Jurassic; *c*, Cretaceous; *d*, Tertiary; T, tide level.

My explanation was as follows:

"The change from the fresh-water plastic clays of New Jersey to the marine beds containing greensand over them proves not only the breaking down of the eastern barrier which protected the former strata from the Atlantic, but a great subsidence also, since glauconite, as a rule, is only deposited in the deep, still waters of the ocean."*

Since my paper was published, I have been over part of this section several times, and found clear indications of the break itself. Moreover, Professor W. B. Clark, of Baltimore, informs me that he finds distinct unconformity between the marine Cretaceous and the underlying Potomac, along the junction of these two formations, at various other points further south. This fact furnishes a strong argument that the marine Cretaceous belongs to a separate formation from the older fresh-water clays, here regarded as Jurassic.

Another geologist who has written much about the West, but seems to have failed in comprehending the evidence afforded by the vertebrate fossils from well-marked Jurassic horizons, is C. A. White, and as his opinion is frequently quoted, it may be well to correct one of his statements which bears on the question here discussed. In speaking of the Atlantosaurus beds, in 1889, he made this statement:

"If it were not for their dinosaurian faunas their Jurassic age might well be questioned."†

When this statement was made, more than one hundred species of vertebrate fossils besides the Dinosaurs were known from these same Atlantosaurus beds, and among these, the Crocodilians, the Testudinates, and the various smaller reptiles would have been sufficient to demonstrate the Jurassic age of the strata containing them. More important still, several hundred specimens of Jurassic mammals had been found, over a score of species were already described and figured, and these alone were sufficient to prove the horizon Jurassic.

* This Journal, vol. ii, p. 441, 1896.

† Proceedings of the American Association, Toronto meeting, p. 213, 1890.

Following these well-known writers, others of less experience in the West have repeated their statements or followed the earlier geologists as to the age of western horizons, and thus tended to continue the confusion where the facts themselves made the whole subject clear. Thus it has come to pass that while the Jurassic formation has been recognized in the Arctic regions of this Continent, and along the Pacific coast, especially through Oregon and California, as well as in Mexico, and likewise in various parts of South America, its development in the Rocky Mountain region has received little attention except from those especially engaged in its investigation. It is not strange, then, that those who have not seen how extensive the Jurassic formation is developed in Europe, and have not examined its characteristic exposures in the West, should fail to recognize it on the Atlantic coast where its features at many points are obscure.

In my paper on this subject last year, I endeavored to show that the burden of proof must rest upon those who denied the existence of the Jurassic formation on the Atlantic border. The evidence against it is still based mainly upon fragmentary fossil plants, in regard to the nature of which the paleobotanists themselves are not in accord.

Cycad Horizons.

I have recorded elsewhere my opinion of the comparative value of different kinds of fossils,—vertebrates, invertebrates, and plants,—as evidence of geological age, and have endeavored to show that plants, as usually preserved and described, are the least valuable witnesses. The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind and stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal Measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

As bearing directly on the question here discussed, the Cycads of the Jurassic period afford instructive examples of the evidence that may be derived from fossil plants under favorable circumstances. The Cycad trunks of the upper Jurassic of England have long been known, and are especially

interesting from the fact that many of them are found imbedded in the original soil in which they grew, thus marking a definite horizon, the age of which has been ascertained by independent testimony.

On the Atlantic border of this country we have a corresponding horizon, determined to be such by its position and by the vertebrate fossils it contains. At various localities in this horizon, especially in Maryland, Cycad trunks have long been known, and within a few years numbers of very perfect specimens have been found under circumstances that serve to fix the horizon in which they occur, and confirm the evidence as to its geological age.

In the Rocky Mountain region, especially around the margin of the Black Hills, a definite horizon likewise exists, in which great numbers of Cycad trunks are found in remarkable preservation. These Cycads resemble most nearly those from Maryland, found in what I term the Pleurocœlus beds of the Potomac formation. In the Black Hills, the age of the horizon has not been accurately determined, but present evidence points to its Jurassic age. The strata here containing these characteristic fossils has long been referred to the Dakota, but, as I have already shown in the present paper, the beds so termed in the Rocky Mountain region are not the equivalents of the original Dakota, and some of them are evidently Jurassic. Until recently the Cycads of the Black Hills, although of great size and remarkable preservation, have not been found actually in place. In the large collection of Cycads belonging to the Yale Museum, a few have been discovered apparently where they grew, and systematic investigation will doubtless show that the various localities where these fossils have been found around the Black Hills are all in one horizon. The evidence now available indicates its Jurassic age, and suggests that it is essentially the same as that of the Cycad beds in Maryland, which I regard as a near equivalent of the well-known Cycad horizon in the Purbeck of England.*

In conclusion, I have only to say that the year which has passed since my first communication to the National Academy on the Jurassic of the Atlantic border has brought no important evidence against the view I then maintained, but much additional testimony in its favor, especially in the region north of the Potomac River that I then discussed. I still hope to return to the subject later, and take up the question of the extension of the same formation along the Atlantic coast further south, and around the gulf border to the southwest, where new evidence is now coming to light.

* W. H. Reed, formerly my assistant in the West, informs me that he has found Cycads in the Jurassic of Wyoming, both in the Freeze Out Hills, and also near the Wind River Range. In the former region, they occur about forty feet above the *Baptanodon* beds, so named from a genus discovered by Mr. Reed.

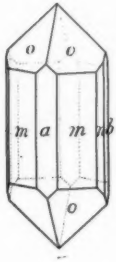
Art. XI.—*Mineralogical Notes;* by C. H. Warren.

1. *On the occurrence of Melanotekite at Hillsboro, New Mexico, and on the Chemical Composition of Melanotekite and Kentrolite.*

The rare mineral melanotekite, a basic silicate of ferric iron and lead, was first described in 1880 from Långban, Sweden, by G. Lindström* It was there found as massive material, but crystals of it from Pajsberg, Sweden, have since been described by Nordenskiöld†, who has shown that they are orthorhombic, and similar to kentrolite, a corresponding basic silicate of manganese and lead. The material to be described in the present paper was recently sent to the Mineralogical Laboratory of the Sheffield Scientific School for identification by Mr. W. M. Foote, of Philadelphia, Pa., and later an excellent specimen was received from Mr. J. H. Porter of Denver, Col. Both parties had obtained their material from Mr. Geo. E. Robin of Hillsboro, New Mexico, who had collected it at the Rex and Smuggler mines at Hillsboro, where it is associated with cerussite and a brown, jasper-like, material. The material has a dark brown to almost black color, and gives an ochre-yellow streak, similar to that of limonite or göthite. The specimens consist for the most part of a rather compact mass of crystals, showing distinct forms in numerous cavities. The largest crystals measured about 0·5^{mm} in length, and considerably less in diameter, and showed the simple combinations represented by Figs. 1 and 2. They were always attached, and frequently in such a manner that both ends of the crystal could be observed.

1.

2.



The forms which have been observed are as follows:

a, 100	*m*, 110	*k*, 150
b, 010	*n*, 130	*o*, 111

Usually *m* and *b* are the only faces in the prismatic zone, but the prism *n* was seen on a number of crystals, while *k* was observed only once. The crystals were always terminated by the pyramid *o*. Considerable difficulty was experienced in selecting crystals from which satisfactory measurements could be obtained, as the faces were not only small, but generally vicinal, thus rendering the reflec-

* Öfv. Ak. Stock., xxxv, No. 6, 53, 1880.
† Geol. Fören. Forh., xvi, 151, 1894.

tions somewhat uncertain, and this same difficulty has been experienced by others who have studied crystals of melanotekite. The crystal which was finally selected as best, however, gave excellent reflections from the pyramid faces, and it is believed that the axial ratio derived from the measurements marked with an asterisk in the accompanying table is very nearly correct. The axial ratio is given below, together with those obtained by Nordenskiöld and Flink from melanotekite and kentrolite, from Swedish localities, and by vom Rath from kentrolite from southern Chili.

Melanotekite*	Author	$a : b : c = 0{\cdot}6338 : 1 : 0{\cdot}9126$
	Nordenskiöld...	$a : b : c = 0{\cdot}6216 : 1 : 0{\cdot}9041$
Kentrolite	Flink	$a : b : c = 0{\cdot}6328 : 1 : 0{\cdot}8988$
	Nordenskiöld ..	$a : b : c = 0{\cdot}6314 : 1 : 0{\cdot}8793$
	Vom Rath.....	$a : b : c = 0{\cdot}6334 : 1 : 0{\cdot}8830$

The measurements and the calculated values of the melanotekite from Hillsboro are as follows:

	Measured.	Calculated.
$o \wedge o$, $111 \wedge 1\bar{1}1 =$	55° 00′ *	
$o \wedge o$, $111 \wedge \bar{1}\bar{1}1 =$	119 13 *	
$o \wedge o$, $111 \wedge \bar{1}11 =$	93 31	93° 32′
$o \wedge m$, $111 \wedge 110 =$	30 24	30 23½
$o \wedge b$, $111 \wedge 010 =$	62 32	62 30
$m \wedge m$, $110 \wedge 1\bar{1}0 =$	64 55½	64 44
$m \wedge n$, $110 \wedge 130 =$	29 34 to 55	29 53
$m \wedge k$, $110 \wedge 150 =$	16 52	17 30

The chemical formulas that have been assigned to melanotekite and kentrolite respectively are $Pb_2Fe_2Si_2O_9$ and $Pb_2Mn_2Si_2O_9$, but as the analyses do not agree in a very satisfactory manner among themselves, nor with the theoretical composition, it seemed very desirable to make a new analysis, and some of the very best material was carefully selected for that purpose. The material was treated for a few minutes with a little warm dilute nitric acid to remove a trace of cerussite which could not be avoided, and further than this no visible impurity could be detected. The specific gravity was taken with great care on the chemical balance and found to be 5·854.

The method of analysis was as follows. The mineral was dissolved in hydrochloric acid, and the silica separated in the usual manner. In the filtrate from the silica lead was precipitated as sulphide, and eventually converted into sulphate and weighed. In the filtrate from the lead the iron was precipitated with ammonia, and weighed as oxide. It was subsequently dissolved and determined by potassium permanganate giving a slightly lower result, but the nature of the difference, X, has not been ascertained.

The results of the analyses are as follows:

	I.	II.	Average.	Ratio.	Calculated for $(Fe_4O_3)Pb_3(SiO_4)_3$
SiO_2	15·51	15·48	15·49	·258 or 3·10	15·40
PbO	55·50	55·63	55·56	·249 3·00	57·23
Fe_2O_3 ...	27·49	27·52	27·51	·171 2·06	27·37
X	·83	·81	·82		———
H_2O	·68	·67	·68		
			———		———
			100·06		100·00

The ratio of $SiO_2 : PbO : Fe_2O_3$ corresponds closely to 3 : 3 : 2 and gives as the composition of the mineral, $Fe_4Pb_3Si_3O_{15}$, which may also be written as a basic salt of orthosilicic acid $(Fe_4O_3)\ Pb_3\ (SiO_4)_3$; the radical (Fe_4O_3) being sexivalent, and the one which occurs in limonite $(Fe_4O_3)\ (OH)_6$.

That the analyses of melanotekite and kentrolite, which have previously been made, have failed to yield formulas corresponding to the above, is probably owing to the fact that the material has not been sufficiently pure. A list of these analyses is given below; the liberty having been taken of changing MnO wherever it was found to its equivalent of Mn_2O_3, since it undoubtedly exists in that condition in kentrolite.

	Melanotekite. Lindström.		*Kentrolite.*			
	I.	II.	Damour.	Flink.	Calculated for $(Fe_4O_3)Pb_3(SiO_4)_3$.	$(Mn_4O_3)Pb_3(SiO_4)_3$
SiO_2..	17·32	17·22	15·95	17·68	15·40	15·45
PbO .	55·26	58·42	59·79	55·72	57·23	57·43
Fe_2O_3	23·18	22·81	....	5·58	27·37	....
Mn_2O_3	·76	·63	22·26	21·18	....	27·12
X*...	3·59	·84	... CaO ·91		....	....
	———	———	———	———	———	———
					100·00	100·00

Following are the ratios derived from the foregoing analyses:

	SiO_2 :	PbO :	R_2O_3	SiO_2 :	PbO :	R_2O_3
Author	·258 :	·249 :	·171 =	3·10 :	3 :	2·06
Lindström I ...	·288 :	·248 :	·148 =	3·51 :	3 :	1·83
Lindström II ..	·286 :	·262 :	·145 =	3·30 :	3 :	1·70
Damour	·265 :	·268 :	·140 =	2·97 :	3 :	1·57
Flink	·294 :	·250 :	·168 =	3·54 :	3 :	2·02

The ratio of $SiO_2 : PbO : R_2O_3$ to correspond to the author's formula should be 3 : 3 : 2, but in all of the earlier analyses except Damour's, the ratio of the silica is a little too high, probably resulting from a slight admixture of quartz or some other silicate, while the ratios of the lead to the sesquioxides in Lindström's and Flink's analyses are nearly 3 : 2. No

*X = CaO, MgO, K_2O, Na_2O, BaO, CuO, FeO, P_2O_5 and Cl.

satisfactory explanation, however, can be given for the low sesquioxides in Damour's analyses. The formulas which have previously been assigned to these minerals are $Fe_2Pb_2Si_2O_9$ and $Mn_2Pb_2Si_2O_9$, respectively, with the ratio of $SiO_2 : PbO : R_2O_3 = 2 : 2 : 1$, and, with the exception of Damour's analyses, it will be seen from the following table of ratios that the agreement is not very satisfactory.

	SiO_2	:	PbO	:	R_2O_3.
Author	2·06	:	2	:	1·37
Lindström I	2·34	:	2	:	1·22
Lindström II	2·18	:	2	:	1·10
Damour	1·98	:	2	:	1·00
Flink	2·36	:	2	:	1·27

From the foregoing it may be seen that the analyses thus far have shown a considerable variation, and with the exception of Damour's analyses of kentrolite, they agree better with the author's formula than with the one that has previously been accepted. The author's formula for melanotekite $(Fe_4O_3)\,Pb_3\,(SiO_4)_2$, is substantiated not alone by the analyses of the mineral from Hillsboro, but it corresponds to a type of basic silicate formula, which is quite common among minerals, namely, three molecules of orthosilicic acid in which six hydrogens are replaced by the sexivalent basic radical $(Fe_4O_3)^{iv}$, and six by three atoms of lead. Moreover, if the formula for melanotekite is correct, the formula of kentrolite must be similar $(Mn_4O_3)\,Pb_3\,(SiO_4)_2$, for the two minerals have almost identical crystallographic relations.

2. Pseudomorphs after Phenacite, from Greenwood, Maine.

The pseudomorphs, which are to be described, were discovered by Mr. G. L. Noyes, of Norway, Maine, at a ledge in the town of Greenwood, and were sent to this laboratory for identification. The crystals are remarkable for their size, and are evidently pseudomorphs, as the faces are rough, in places pitted, and in the depressions perfectly developed quartz crystals are visible. A thin section, when examined under the microscope, showed that the material consisted of quartz and a mineral with a foliated or mica-like structure. The color of the crystals is white with a slight greenish cast. It is evident that the crystals were originally attached, and they had been broken from the matrix, so that they thus presented only a portion of the crystal faces, and although the habit differs from that of phenacites which have been described, the characteristic forms and the peculiar symmetry of the crystals render it almost certain that they must be pseudomorphs after that rare mineral. The following forms were observed :

m, $10\bar{1}0$ μ, $02\bar{2}1$ s_1, $3\bar{1}\bar{2}1$
d, $01\bar{1}2$ s, $21\bar{3}1$

The development of the faces is shown in Fig. 3, which represents the smaller crystal weighing 2 lbs., and measuring $4\frac{1}{2}$ inches in diameter, and Fig. 4, representing a crystal 12 inches in diameter, and weighing 28 lbs. If the faces had been symmetrically developed in about the proportions represented by these two partial crystals, the complete form would appear like

3 4 5

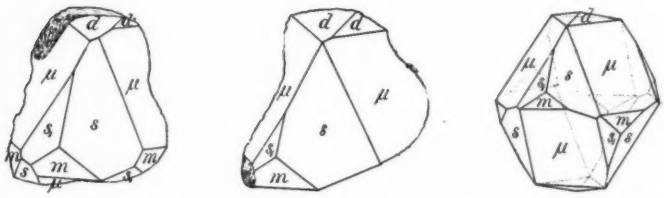


Fig. 5, which differs from previously described crystals of phenacite, in that the μ, s and s_1 faces are unusually prominent, while, when prismatic forms are developed, generally the prism of the second order a is prominent instead of m.

Owing to the rough character of the faces, only approximate measurements could be made with the contact goniometer, and these are given in the accompanying table, together with the values calculated from the measurements of Koksharov*

	Measured.	Calculated.
$m \wedge m$, $10\bar{1}0 \wedge 01\bar{1}0$ =	60°	60°
$d \wedge d$, $01\bar{1}2 \wedge 1\bar{1}02$ =	36	35 58½′
$m \wedge \mu$, $01\bar{1}0 \wedge 02\bar{2}1$ =	33	33 14
$m \wedge \mu$, $10\bar{1}0 \wedge 02\bar{2}1$ =	66	65 16½
$\mu \wedge \mu$, $02\bar{2}1 \wedge 2\bar{2}01$ =	92	92 50
$m \wedge s$, $10\bar{1}0 \wedge 21\bar{3}1$ =	33	32 8
$d \wedge s$, $01\bar{1}2 \wedge 21\bar{3}1$ =	50	48 59
$s \wedge s_1$, $21\bar{3}1 \wedge 3\bar{1}\bar{2}1$ =	35	34 2

A determination of the bases was made on a portion of material which was decomposed by hydrofluoric and sulphuric acids, and gave the following results:

Al_2O_3	19·30
Fe_2O_3	·54
Li_2O	·68
Na_2O	1·17
K_2O	·67
H_2O	5·53
	27·89
Quartz and combined silica by difference	72·11

* Materialen zur Min. Russland, ii, p. 308, 1857

The high percentage of water and alumina, and low percentages of alkalies, probably indicate the presence of cookeite, which has been observed as a secondary mineral on other specimens from the locality. Careful tests were made for beryllium with negative results.

3. *Supposed Pseudomorphs after Topaz from Greenwood, Maine.*

In connection with the pseudomorphs just described, there occur other pseudomorphs of quartz after a prismatic, and probably an orthorhombic mineral. The crystals are prisms about 4 inches in length, having an angle about like the prism *m*, 110, of topaz, and are terminated by basal planes. It seems most probable that they are pseudomorphs after topaz, but the original material has been wholly removed, and the crystals now present the appearance of a shell of quartz, with the points of innumerable crystals projecting outward, while within they are cavernous, and the sides of the cavities are lined with small quartz crystals, and rounded prominences of cookeite.

4. *Crystallized Tapiolite from Topsham, Maine.*

In a recent article by Brögger* it has been shown that the isomorphous molecules RNb_2O_6 and RTa_2O_6 (R = Fe and Mn) are also *dimorphous*, there being the *orthorhombic* minerals columbite RNb_2O_6 and tantalite RTa_2O_6 and corresponding to them *tetragonal* species mossite and tapiolite. It was moreover shown that the mineral skogbölite from Tammela, Finnland, described by Nordenskiöld† as orthorhombic, is identical with the tapiolite from Tammela, also described by Nordenskiöld,‡ the apparently orthorhombic habit of the skogbölite resulting from a twinning of a tetragonal crystal about a pyramid of the second order 101, and an extension of some of the pyramidal faces into a prismatic form. Crystals of the tetragonal mineral rutile with an apparently orthorhombic habit like that of tapiolite, and due to a similar twinning, have been described by Pirsson§ and Miklucho Maclay‖

The tapiolite crystals to be described here are from the feldspar quarries of Topsham, Maine, and the following forms have been observed on them :

a, 100	*e*, 101	*p*, 111
m, 110	s, 201	*x*, 133

* Über den Mossit and über das Krystallsystem des Tantalit (Skögbolit) aus Finnland, Videnskabsselskabets Skrifter, I Mathematisk-natur Klasse, 1897, No. 7. Kristiania.

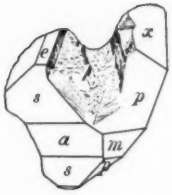
† Beskr. Finn. Min., 30, 1855.

‡ Öfv. Ak. Stockh., xx, 445, 1863.

§ Am. J. Sc., xli, 249, 1891.

‖ Jb. Min., ii, 88, 1885.

6.



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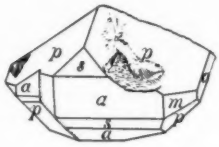

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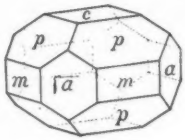


A crystal obtained from Mr. L. B. Merrill of Paris, Maine, and now in the Brush collection at New Haven, has the habit shown in fig. 6. This crystal is apparently not twinned. Its diameter is about 18^{mm} and specific gravity 7·67.

Fig. 7 represents a crystal belonging to Mr. T. F. Lamb of Portland, Me. This crystal is a twin, measuring about 2^{cm} in diameter and having a specific gravity of 7·68. The crystal faces are rough, and they show, when examined with a lens, a superficial growth of minute prismatic crystals in twin position, and crossing at angles of about 60°. The surface of the crystal resembles some of the brookite crystals from Magnet Cove, Arkansas, with a growth of rutile crystals in twin position upon their surface.

Fig. 8 represents a simple and almost ideally symmetrical crystal, about 5^{mm} in diameter and with a specific gravity of 7·87, loaned by Mr. J. S. Towne of Brunswick, Me.

9.

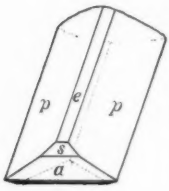


Fig. 9 represents a very symmetrical twin crystal also loaned by Mr. Towne. It has a length of 2^{cm}, a breadth of 1^{cm}, and the specific gravity is 7·66.

The high specific gravity of these tapiolite crystals indicates that they are essentially tantalates and contain very little niobium, as has also been proved by qualitative chemical tests. They contain iron as the base, and give only a very slight reaction for manganese.

The measurements given in columns I, II and III were obtained from the crystals represented by fig. 6, 8 and 9 respectively, and the calculated values are obtained from the measurement given by Nordenskiöld $p \wedge p$, $111 \wedge \bar{1}\bar{1}1 = 84° 52'$.

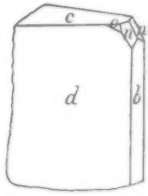
	I.	II.	III.	Calculated.
$111 \wedge 1\bar{1}1$	----	----	57° 1′	56° 59½′
$p \wedge p$, over twinning plane,	123° 1½′	122° 59′	----	123 ½
$100 \wedge 111$	61 30½	----	61 28½	61 30
$110 \wedge 111$	47 34	----	47 26½	47 34
$101 \wedge 111$	28 25	28 26½	----	28 29¾
$100 \wedge 301$	27 10	27 12	----	27 29
$111 \wedge 133$	18 3		----	18 14

5. *Crystallized Tantalite from Paris, Maine.*

There are also in the Brush collection a few small specimens of tantalite received from Mr. L. K. Stone of Paris, and identified by Prof. Penfield. The specific gravity of the crystals is very high, 7·26, thus indicating that they are tantalite and not columbite. They contain iron, and little or no manganese, which adds to the interest connected with them, since the crystallized tantalite previously described has been of the manganese variety. Only a very little material was found and it is not well adapted for crystallographic study as the faces of the crystals are dull, but sufficiently accurate measurements could be obtained to identify the forms, which were found to correspond to well-known ones on columbite. The habit of one of the crystals is shown in fig. 10, and fig. 11 represents the arrangement of the faces on the corner of another crystal. The forms that were identified were as follows:

10.

11.



a, 100	*c*, 001	*m*, 110	*o*, 111
b, 010	*d*, 730	*g*, 130	*n*, 163

The measured angles are given below, and since the measurements could not be made with sufficient accuracy for establishing an axial ratio for the iron tantalate, they are compared with the angles of columbite, derived from the axial ratio established by E. S. Dana.*

		Measured.	Calculated.
$b \wedge g$,	$010 \wedge 130 = 20° 35'$		$21° 55'$
$b \wedge m$,	$010 \wedge 110 = 49$		50 21
$b \wedge d$,	$010 \wedge 730 = 70$	15	70 27
$b \wedge a$,	$010 \wedge 100 = 91$		90
$b \wedge n$,	$010 \wedge 163 = 31$	15	30 50
$n \wedge n$,	$163 \wedge \bar{1}63 = 19$	30	19 54
$o \wedge o$,	$111 \wedge \bar{1}\bar{1}1 = 61$	30	62 27

6. *Cobaltiferous Smithsonite from Boleo, Lower California.*

This mineral was sent to this laboratory for identification, by Mr. Geo. W. Fiss of Philadelphia, and was supposed to be the rare hydrated cobalt carbonate, remingtonite, the composition of which is not known. The mineral consists of little

* Zs. Kr., xii, 266, 1886.

crystalline particles of a delicate pink color, imbedded in gypsum and associated with a little atacamite. The mineral was first carefully selected from all material of a green color by hand picking, and was then crushed and sifted to a uniform grain, and treated with the heavy solution to separate the lighter portion. The heavy portion when examined under the microscope was apparently very pure. The specific gravity was found to be 3·874, and an analysis gave the following results:

	I.	II.	Average.	Ratio.	
CO_2	36·89	36·99	36·94	·839	·839
FeO	·33	·33	·33	·004	
ZnO	39·03	39·01	39·02	·481	
CoO	10·27	10·24	10·25	·126	·838
MnO	3·40	3·32	3·36	·047	
MgO	7·00	7·43	7·22	·180	
CuO	1·63	1·67	1·65		
Cl	·11	----	·11		
H_2O	1·24	1·34	1·29		
			100·17		

Regarding the small amounts of CuO, H_2O and Cl as impurities, resulting possibly from a slight admixture of atacamite, the ratio of CO_2:(Zn+Co+Mn+Fe+Mg)O is ·839 : ·838 or almost 1 : 1, indicating that the mineral is a normal carbonate, and essentially a zinc carbonate, smithsonite, in which the zinc is partially replaced by cobalt, manganese and magnesium.

In conclusion the author desires to express his thanks to those gentlemen, whose names have been mentioned in this paper, for their kindness in placing their specimens at his disposal, and especially to Prof. S. L. Penfield for the valuable advice and assistance which he has rendered during the investigation.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School.

Art. XII.—*The Origin and Significance of Spines: A Study in Evolution;* by Charles Emerson Beecher.

[Continued from page 20.]

Categories of Origin.

As previously shown, spines are formed either by growth or by suppression, and therefore the processes determining their production are either constructive through concrescence or destructive through decrescence. Each of these is in turn determined by forces from without the organism (extrinsic) or by forces from within (intrinsic). In this connection, it is of no especial moment whether or not the intrinsic forces are primary or are an immediate or subsequent reflex from the extrinsic. The main thing is the direction of the dominant force, whether centripetal or centrifugal. If, in some cases, it can be shown that spine development has been accomplished by intrinsic forces in the organism, then this development may be brought about independently of the environment and possibly at variance with it. Also, if in other cases, the extrinsic forces or the influences of the environment have caused spine growth, it may in some instances illustrate the formation and transmission of an acquired character, or at least the operation of organic selection.

The point has now been reached where it is impracticable to make a rigid classification of the direct factors or an exact determination of primary and secondary causes. It was remarked at the beginning of this paper, that single causes were not sufficient in every case to account for spine growth, and while it is comparatively easy to formulate abstract expressions or terms covering all possible cases, it will be found difficult to construe properly certain factors to fit into any particular conception. In illustration of this, the foregoing statements may be taken. Thus, spines are formed by the only means possible, either by growth of new tissue or by decrease in old. Again, the forces must act from the interior or from the exterior; in other words, they must be intrinsic or extrinsic. But in some specific instance, while considering food, forces of nutrition, external or internal demands, reactions, etc., a question may arise as to the proper disposition to make of a spine developing primarily by external stimuli and becoming a defense and secondarily a weapon; yet which by differentiation in time loses some of its protective and offensive qualities, and by selection may be confined to one sex.

Growth and decline are underlain by the processes taking place in individual cells as well as in aggregates of cells, for spine growth must be considered in unicellular as well as multicellular organisms.

Ryder[61] has very philosophically discussed the correlations of volumes and surfaces of organisms, and has reached the conclusion that "the physiological function of a cell is also a function of its figure, i. e., of its morphological character; that is to say, cells tend to elongate in the direction of the exercise of their function." Out of this may be deduced the correlative conclusion that aggregates of cells having a like function also tend to elongate in the direction of the exercise of this function; and, further, it may be asserted that parts or portions of cells will act in the same manner.

A familiar illustration of these principles as applied to a single cell may be taken from the Rhizopod, *Amœba proteus*. When disturbed by incident forces in all directions, it assumes a globular form. Under continuous motion of its own, it is elongated in the axis of motion, its larger pseudopodia being thrust out in more or less the same direction. The presence of a favorable exciting cause, like a particle of food, produces extension of the protoplasm to envelop it.

Furthermore, as is well known, continuous extra-pressure on any part of an organism produces atrophy and absorption, and intermittent or occasional pressure causes hypertrophy and growth. That the pressure should be intermittent, seems a necessary condition for hypertrophy, in order that the parts affected may have normal intervals allowing the active exercise of nutrition.[55] This may be regarded as a parallel statement of the law of disuse and use; the former causing organs or parts to dwindle away and lose their function, and the latter producing increased nutrition and growth.

This ratio of exchange between nutrition and waste is on the side of full or excessive cell-nutrition, producing growth in the parts affected, while deficiency of nutrition produces decline or suppression. If the successive increment constituting growth is along definite progressive lines towards higher structures, and the decrement affects the decline of useless parts or permits of the replacement of a lower by a higher structure, then the sum of the changes is progressive evolution.*

Growth, as stated, seems to require normal intervals for the proper exercise of nutrition, which involves an intermittence of the exciting or stimulating forces. Rhythm has been shown by Spencer[66] to be a necessary characteristic of all motion, and therefore in considering either the intrinsic or

* This is very near Cope's idea of progressive evolution.

extrinsic forces acting on the structures of an organism, they must be rhythmic or intermittent. In the environment, the most apparent changes are those of light and darkness, heat and cold, moisture and dryness, and variations in amount of oxygen, all of which affect an organism directly, and also through the accompanying variations in the character and amount of the food supply, the number of enemies, etc. These and most of the mechanical forces of the environment are therefore intermittent, and their resultant must have a definite tendency, so that the effects are not with each change successively positive and negative to the same degree; that is, the same structures or adjustments are not alternately made and unmade.

It is generally recognized that there is a necessity for a force or energy in living organisms, which is not the immediate and direct result of external agencies, but upon which these fall and produce reactions. It is considered as a phase or kind of vital force directing growth, and therefore a growth force, or the bathmic force of Cope.[10] The internal energy of growth, involving the capacity or effort of responding to external stimuli, is termed entergogenic energy by Hyatt.[34] Without this power, an organism would be unable to move or respond to external stimuli. The effect of the action of this kind of energy must be the resultant between "the structures already existent in the organism and the external forces themselves."[34] Since the growth force is within the organism, or inborn, it is one of the principal characters transmitted through heredity, and if it is in excess of the external forces, the modifications will be principally congenital or phylogenic. If, on the other hand, the external forces predominate, the modifications will be principally adaptive, or ontogenic. In each case, the resultant is the actual visible effect of the two. If both are toward the establishment of similar structures, their effect will be the sum of the two; but if they are opposed to each other, the effect will be their resultant, the nature of which, as seen above, will depend upon their relative power.

These conclusions can be correlated directly with the developmental variations occurring in the life history of any great group of organisms. Anyone who has studied the chronological development or the phylogeny of a class of forms cannot fail to have been impressed with the fact, that all types of life are physiologically more plastic or subject to greater changes near their point of origin. That is, the maximum of generic, family, and ordinal differentiation is found at an early period, while the greatest specific differentiation occurs at a later period. This shows that the results of variation at first affect the

physiological and internal structures, and that later the changes are mainly physical and peripheral.

One explanation of this would be that the forces of the environment are at first freely transmitted and produce internal modifications, and that later these characters become stable, making the effects of the external stimuli apparent in the superficial differentiation of the organisms.

In any event, the modifications in function and structure are followed by modifications in surface, showing that the more important physiological and structural variations are the first to be subjected to heredity and natural selection, which tend to fix or hold them in check. Features of less functional importance, as peripheral characters, are the last to be controlled, and therefore present the greatest diversity, while in this diversity spinosity is the limit of progress. In order to be hereditable, the modifications through the environment must have induced correlative internal adjustments and changed forces which can be transmitted to offspring, and they in turn reproduce the specific modifications.

For the purpose of illustrating these statements, the evolution of the Brachiopods and Trilobites will be taken. The Brachiopods are divided into four orders, all of which appear in the Lower Cambrian and continue to the present time. Schuchert[6] states that "of the 49 families and subfamilies constituting the class, 43 became differentiated in the Paleozoic, and of these 30 disappeared with it"; also, "of the 327 genera now in use, 227 had their origin in Paleozoic seas, or nearly 70 per cent of the entire class." Throughout the Cambrian, "differentiation was mainly of family importance." "Differentiation is most rapid near the base of the older systems, and diminishes the force from the older to the younger geologic divisions." The most rapid increase was in the Ordovician, the culmination was in the Devonian, and the rapid decline came with the Carboniferous. About six thousand species are known, and of these probably not more than one hundred and fifty are living.

Similar data are derived from the Trilobites. This group is found all through the Paleozoic, at the close of which it became extinct. Two of the three orders are found in the Lower Cambrian. The remaining order appeared just after the close of the Cambrian in the early Ordovician, yet through the whole of the remaining sediments not a single new ordinal type was enveloped. When applied to a single order, the same truth comes out. The order Proparia is one whose entire history can be traced, extending from the Ordovician through the Silurian and Devonian. All the families appear in the Ordovician; in fact not a single family type in this or

the other orders was produced during the whole Silurian, Devonian, and Carboniferous.[6]

As the classes, orders, and families are based upon the physiological and important functional structural characters or differences, it is evident that at or near the beginnings of their life history is found the demonstration of the domination of phylogenic over ontogenic characters.

Conditions or forces affecting growth.—Since spines are purely organic structures, their production must follow the general laws of organic change. The forces considered as of most consequence are two: (1) the external stimuli from the environment, and (2) the energy of growth force. These, with their opposites (1*a*) the restraint of the environment, and (2*a*) the deficiency of growth force, are believed to include the chief active and passive causes, not only of spine production, but of growth and decline in general. Correlating these four causes with their constructive and destructive agencies, together with their extrinsic and intrinsic modes of action, as previously explained, there result (A) the external stimuli of the environment as an extrinsic cause of concrescence; (B) energy of growth force as an intrinsic cause of concrescence; (C) external restraint as an extrinsic cause of decrescence; and (D) deficiency of energy of growth force as an intrinsic cause of decrescence. The remaining vital forces (nerve force, or neurism, and thought force, or phrenism) are not primary, and, although doubtless affecting growth in higher organisms, cannot be original causes applicable to all forms of life, both plant and animal.

In tabular form, the divisions and relationships of the factors of spine genesis may be expressed as follows:

Spines originate by
- Constructive agencies (concrescence) acting
  - extrinsically (centripetally) — A — from external stimuli
  - intrinsically (centrifugally) — B — from growth force
- destructive agencies (decrescence) acting
  - extrinsically (centripetally) — C — from external restraint
  - intrinsically (centrifugally) — D — from deficiency of growth force

Under the last four divisions (A—D), it is proposed to discuss the origin of spines, and from the observations made, to derive certain conclusions regarding the significance of the spinose condition.

A. *External Stimuli.*

Under external stimuli are included all the forces of the environment (chemical, physical, organic, and inorganic) which, through their impact or influence on an organism, produce a consonant favorable change or disturbance. In general, it will be seen that the number of impressions and their power will depend largely upon the position and character of the surface upon which they impinge. The more exposed the position, the greater will be their strength and number, and if these stimuli or impressions are intermittent, and not so violent as to produce waste and rupture, growth will ensue. Under ordinary conditions, exposed parts will naturally be the first to receive sufficient stimulus to produce growth, and there will be normally a direct correlation between growth and stimulus. In a simple diagrammatic form, this would be expressed by a series of lines, the first representing a plane surface. Then, owing to the impossibility of maintaining a uniformly intermittent stimulus or a uniform response, some point or spot on this surface would grow in excess of the others. This difference would be augmented by the more favorable position of the spot to receive stimuli, further growth would take place, the growth force decreasing with the increase of distance, and the final action of these forces, stimulus and growth, would be to produce a pointed elevation. Such structures or outgrowths, especially when made of hard rigid tissue, would be termed spines under the general definition. The spine may be viewed as an attached organism, and its conical habit of growth would then conform to the law of radial symmetry, as determined by the physiological reaction from equal radial exposure to the environment. That all the irregularities of contour in all organisms have not developed into pointed processes or spines is not, therefore, the fault of the simple reciprocity between growth and external stimuli. This kind of development, however, requires a direct and immediate responsive external growth to the exciting force, which from various causes is frequently absent. Obviously, stimuli which result simply in motion or equivalent internal adjustments can have no effect toward spine production, so that only the results of such stimuli as bring about some accompaniment of superficial growth will be considered.

With the exception of perfectly spherical, freely moving forms, all organisms have certain parts which are more exposed to the forces of the environment than others, and from the principles already enunciated, such exposed parts under normal conditions will grow. This growth in the direction of

function and stimulus, when acted upon by the hereditary functional and structural requirements of the organism, serves to produce the various external organs and appendages. But when the surface upon which the stimuli fall is not thus predetermined by heredity to grow into a certain organ or functional part, there results a normal responsive action between growth and stimulus, which, as already seen, tends to produce a conical or spiniform growth.

Under ordinary favorable conditions, simple external stimuli acting blindly through no agencies of selection would develop spines on all the most exposed parts, and tend to differentiate ornamental features. This has been the case with many organisms and colonial aggregates possessing no power of selection or not acted upon by any forces of determination, conscious or unconscious. In such cases, spines may or may not serve for protection, and their function, if any, can be only determined separately for each case. If, however, the added function of offense is included, it is manifest that the spines must be located in special positions adapted to use for offensive purposes as on the tails of some animals and not necessarily over vulnerable parts. Here the selective agency of special adaptation is shown. Again, if while there is agreement in other essential characters, spines or horns are confined to either sex, it is evidently a case of sexual selection. Further, if they develop in harmony with the environment, or in a manner parallel to similar features of other organisms, it is through the operation of physical selection.

Altogether, under the general forces of external stimuli, there are five aspects in which to consider the production and growth of spines, viz:

A. *From External Stimuli.*

A1.—In response to stimuli from the environment acting on the most exposed parts.

A2.—As extreme results of progressive differentiation of ornaments.

A3.—Secondarily as a means of defense and offense.

A4.—Secondarily from sexual selection.

A5.—Secondarily from mimetic influences.

B. *Growth Force.*

In unicellular organisms, growth force, or bathmetic energy, must reside wholly in the germ cell, and therefore is concerned with reproduction as well as with cell differentiation. In multicellular organisms, the growth force is in both germ and soma cells, and its relative strength seems to depend upon

its power to reproduce lost parts, often including germ cells as well as soma cells. In many of the lower classes, the growth force is able to complete a structure or lost part without the stimulus of use, which in higher animals often seems to be part of the necessary requirements for growth.

Growth itself is the repetition of cells under nutrition and stimulus, and the latter may be hereditary or extra-individual. It is now recognized that since the division of a cell makes two unlike cells, each unlike the parent, such repetition will produce structures which present some degree of difference. The variation is therefore a necessary quality of growth, and its degree will change in response to the differentiation of the forces affecting growth.

When spines which have arisen from intrinsic growth force only are sought, it is apparent that they cannot be distinguished from those arising from external stimuli acting on and directing the growth force, unless, in some instances, they are found to be developed independently or even at variance with the environment. Because spines are sometimes useful to the organism, it is impossible to believe that they have originated from that cause, since their existence in some form must precede the capacity of making them useful. After they began to develop by either intrinsic or extrinsic forces, their being found useful would simply tend to their conservation and further development.

Variation which is not restricted by natural selection or a long line of hereditary tendencies is known as free variation. It is best exhibited in a stock which occupies for a considerable time a region favorable in respect to food, climate, and absence of dominating natural enemies. This relation has been called the period of "Zoic maxima" by Gratacap,[23] and has been further discussed by the same author, under the aspect of numerical intensity.[22] The most rapid rise of a stock is considered to be consequent to a favorable environment and high vitality.

In illustration of these points, the Achatinellæ of the Sandwich Islands afford a good example. The great number of species on these islands has probably been evolved since Tertiary times, and the process of specific delimitation is apparently still going on, for species are now to be found which did not exist fifty years ago (Verrill); also, a few species formerly common are now obsolescent or extinct. According to Hyatt, they all can be deducible from a single species which has differentiated in time through divergence, dispersion, and colonial isolation. In early times, birds may have fed upon them, but the complete or partial extinction of the former by man has resulted in complete immunity for the arboreal Achatinellæ,

and it is now common to find several of the most highly colored varieties feeding together on the same leaf. The modern importation of pigs, sheep, and mice on the islands has introduced an enemy to the terrestrial species, the effects of which are already being noticed. In specific differentiation and in individual variation, both Hyatt and Verrill regard the extraordinary development of this type as characteristic of free variation, under favorable conditions, in a plastic stock which has not yet reached its limits nor become fixed.

Among the Crustacea, the remarkable evolution of the genus *Gammarus* in Lake Baikal,[17] and of *Allorchestes* in Lake Titicaca,[19] seem to furnish parallel examples. *Allorchestes* ranges from Maine to Oregon and southward, through the United States, Mexico, and South America to the Straits of Magellan. Before Lake Titicaca was explored, but one or two authentic freshwater species were known from both continents; yet from this lake basin alone, Faxon[19] has described seven distinct species, constituting the entire Crustacean fauna with the exception of a species of *Cypris*. Several species are "remarkable among the Orchestidæ for their abnormally developed epimeral and tergal spines." These and the species of *Gammarus* from Lake Baikal will be referred to again later in this paper. It is simply desired here to indicate that these variations in *Achatinella* and *Allorchestes* have arisen from a single parent stock, within a small geographic province. The natural interpretation seems to be (*a*) that the environment is favorable, as evinced from the great number of individuals; (*b*) that this has favored and increased the growth force; and (*c*) that, finally, the law of multiplication of effects, reproductive divergence,[67] the survival of the unlike, and the conservative forces of natural selection and heredity have directed the growth force, and produced the specific differentiation which is now found.

A factor of Evolution, called "Reproductive Divergence" by Vernon,[67] seems to be operative here, since it affords an explanation for a means of differentiation in a single stock under a common environment. As this factor has but recently been discussed, it may well be defined at this time, so as to enable a direct application to be made. Reproductive divergence assumes that in many species there will be greater fertility between individuals similar in color, form, or size, than between individuals not agreeing in these respects, and that in subsequent generations, the divergence will become progressively greater in respect to the characteristic in question, so that finally the original stock will become separated into distinct varieties, sub-species, or species.

When, from any cause, the forces of nutrition are directed toward spine production, and when the direct results are accomplished in the reciprocal formation of one or more spines, there is often an apparent inductive influence or impulse given to growth toward the further production or repetition of spines. This may result in the formation of compound spines, or a group of spines, or even produce a generally spinous condition.

Naturally, spines arising through growth force may be useful for defense and offense, and the selective influences of sex and mimicry may also tend to greater development and elaboration. Furthermore, growth forces reacting on any external structures, as lines, lamellæ, ribs, nodes, etc., may tend to differentiate such ornaments into spines.

Therefore, under the general consideration of spines produced through growth force, the following factors are offered for consideration:

B. *From Growth Force.*

B 1.—Prolonged development under conditions favorable for multiplication.

B 2.—By repetition.

B 3.—Progressive differentiation of previous structures.

B 4.—Secondary development through the selective influences of defense, offense, sex, mimicry, and other external demands.

C. *External Restraint.*

Intermittent stimulus, as previously shown, produces growth in the direction of function. When the growth equals the waste, an equilibrium or static condition is reached, and no relative change occurs. The absence of either extrinsic or intrinsic stimulus will not be favorable to growth, and under such conditions, an organ or structure may remain undeveloped, or, if already present in the organism, it may waste away and degenerate into a vestigial structure, or even disappear altogether.

On the other hand, it is well known that continuous pressure not only prevents growth, but in addition resorption takes place, and in this way, the whole or a portion of a structure may be removed. These changes have frequently been studied in embryos, as well as in many internal structures, and are also familiar in the enlarged pedicle openings of many Brachiopods, caused by pressure of the pedicle, and in the similar opening for the byssal plug of *Anomia*. Packard[54] gives examples among the Crustacea and Insects, which are clearly to the point. He says of the Crustacea, "It may here be noted that the results of the hypertrophy and overgrowth of the two

consolidated tergites of the second antennal and mandibular segments of the Decapod Crustacea, by which the carapace has been produced, has resulted in a constant pressure on the dorsal arches of the succeeding five cephalic and five thoracic segments, until as a result we have an atrophy of the dorsal arches of as many as ten segments, these being covered by the carapace."

The restraint of the environment through unfavorable conditions is the antithesis of A, or the influence of constructive external stimuli, and is considered as the extrinsic operation of destructive agencies. It is evident that external unfavorable conditions will repress growth, with a resultant atrophy of the structures affected. In this way, also, the environment may cause the disuse of an organ, which by consequent suppression may dwindle away to a spine, as in the leaves and branches of desert plants, and the spurs of the Python[60] representing the hind limbs. It may likewise repress growth, as in the spines on the lower side of the poriferous coral, *Michelinia favosa*,[40] representing aborted attempts at budding, the failure being due to the unfavorable position of the buds for securing food.

The restraint of the environment may also act in a mechanical manner to produce spines, as will be shown subsequently in some Brachiopods and Trilobites. Furthermore, spines arising through any phase of external restraint, may secondarily come under the influences of natural selection, and be useful for protection and offense, or conform to other external demands.

Under the head of external restraint, therefore, are the following categories:

C. *From External Restraint.*

C 1.—Restraint of environment causing suppression of structures.

C 2.—Mechanical restraint.

C 3.—Disuse.

C 4.—Secondarily for protection, offense, etc.

D. *Deficiency of Growth Force.*

The growth force in organisms may be reduced in several ways, the most general and obvious modes being by an unfavorable environment, lack of physiological plasticity, too close interbreeding, pathologic influences, and parasitism. The first commonly implies a scarcity of food, or it may be that the temperature, moisture, light, elevation, or other conditions are unsuitable to the normal development. The lack of physiological plasticity affects growth force by its resistance to change, and is most strongly apparent in highly specialized forms. The

effects of close interbreeding in reducing vitality are too well known to require farther notice.

Only in exceptional instances can individual pathologic conditions have any effect on a stock. The retrogressive series of animals which are diseased in appearance, and are considered by Hyatt[34] as akin to pathologic distortions, are apparently types which have ceased to advance physiologically, and are therefore only adapted to special sets of conditions. In these, the pathologic or abnormal condition is racial instead of individual, and its cause seems to be a deficiency of vital power combined with great external differentiation, the final result being the assumption of characters belonging to second childhood and ending in extreme senility, with the loss of spines and other ornaments.

The life history of parasitic organisms shows their origin from higher normal types by a process of retrogression through loss of motion and disuse of parts. Their mode of living implies dependence upon the vitality of an immediate host, and altogether they may be deficient in the energy of growth force.

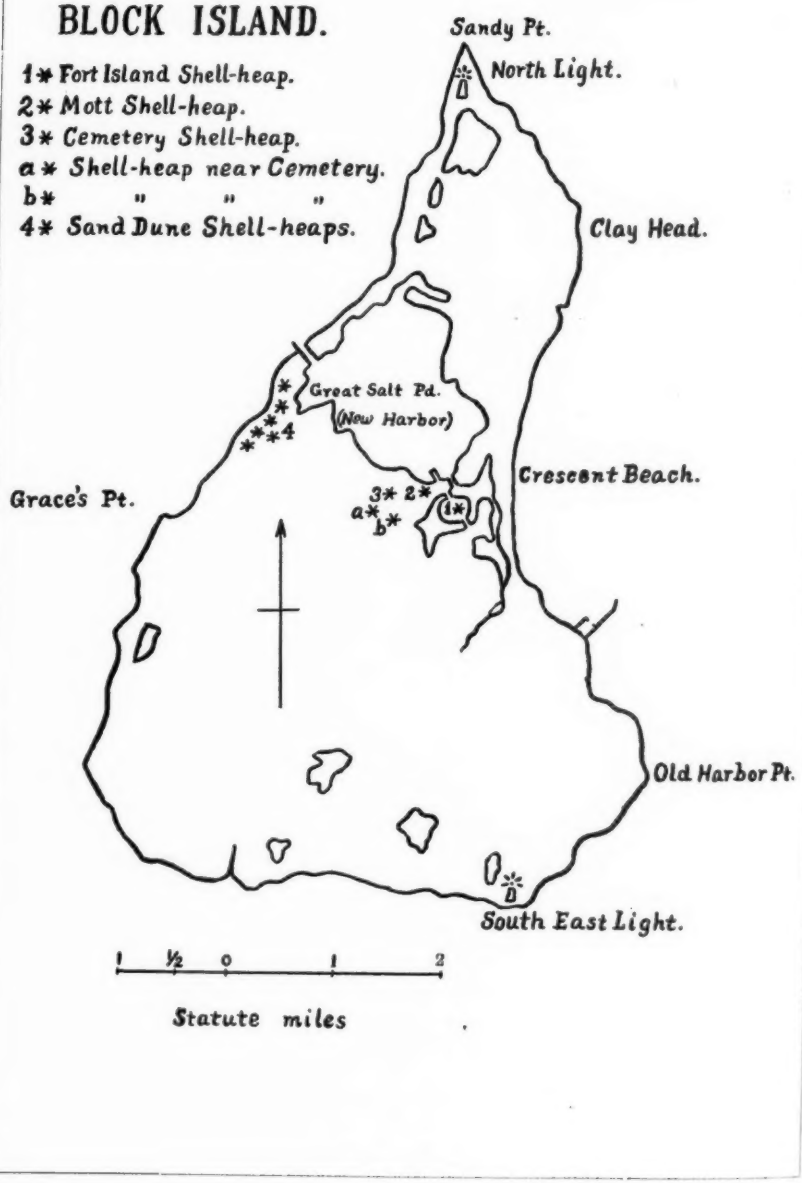
Any of the preceding factors, single or combined, acting upon an organism or group of organisms will produce suppression of structures or functions. Whether from external or internal causes, the waning and disappearance of characters are almost always inversely to the order of their development or appearance, either in the race or in the individual, and the most primitive or axial characters are therefore the most persistent and the last to disappear. In this way, a leaf may be suppressed into a spine representing the midrib, a branch into a spiniform twig, a leg or digit into a spine, etc. As in other primary causes of spine genesis, there may also come secondary influences of protection, offense, etc., controlled by natural selection.

It will be convenient to consider spine production from lack of growth force under three heads:

D. *Deficiency of Growth Force.*

D 1.—Intrinsic suppression of structures and functions.
D 2.—Disuse.
D 3.—Secondarily for protection, etc.

[To be continued.]


BLOCK ISLAND.
1* Fort Island Shell-heap.
2* Mott Shell-heap.
3* Cemetery Shell-heap.
a* Shell-heap near Cemetery.
b* " " "
4* Sand Dune Shell-heaps.
Sandy Pt.
North Light.
Clay Head.
Great Salt Pd.
(New Harbor)
Crescent Beach.
Grace's Pt.
Old Harbor Pt.
South East Light.
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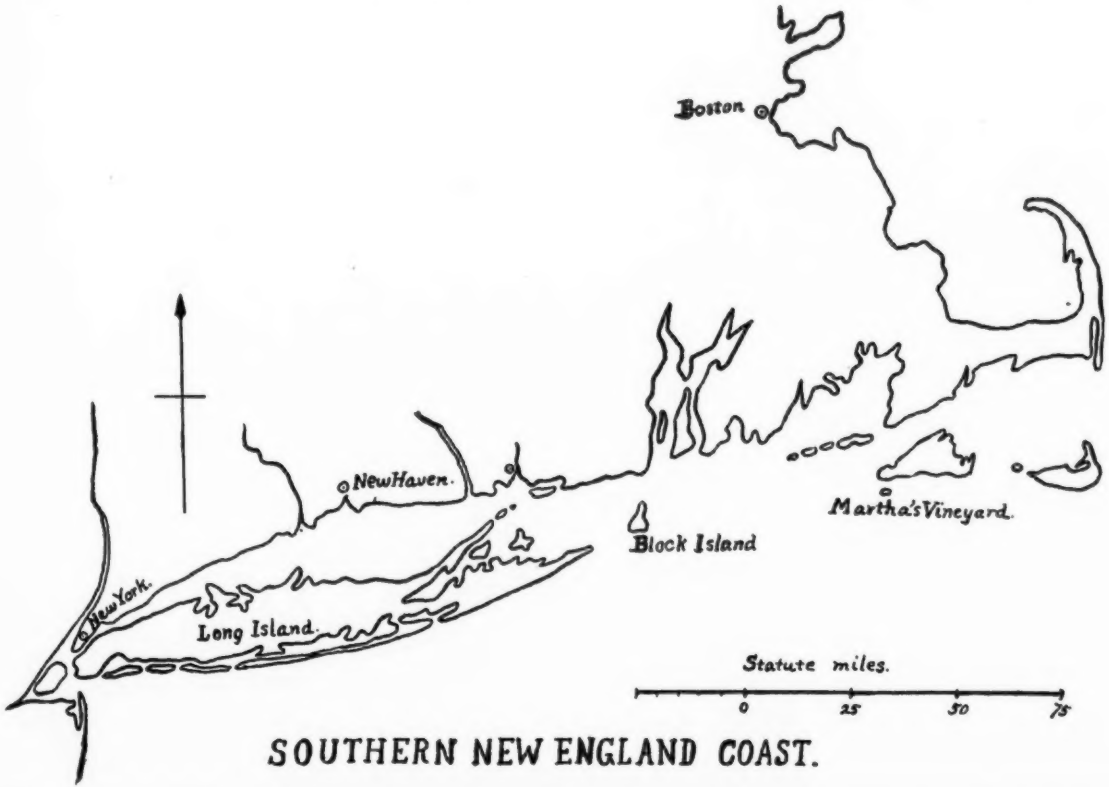


SOUTHERN NEW ENGLAND COAST.

Am. Jour. Sci., Vol. VI, 1898.

ART. XIII.—*The Prehistoric Fauna of Block Island, as indicated by its Ancient Shell-heaps;* * by G. F. EATON. (With Plates II and III.)

Introduction.

BLOCK Island is well known to New England people, both as a healthful summer resort and as a fishing station of great importance. Its fame, moreover, dates back to the remote years before the coming of the first white men, for the legends narrated to the settlers by the former Indian inhabitants, the Manissees, tell of long-continued wars of conquest waged for the sake of the highly prized fisheries. Little is known of this Manissean colony except that they were originally of the same stock as the warlike Narragansett tribe, and that, at the dawn of New England history, they had already occupied the Island during a period of time so long that they themselves had no idea when their ancestors came. A conquered race, they have passed away with the advance of civilization, until now their very name is almost forgotten. Few records are extant which give any information about the manner of life of these aborigines. What food could they procure upon a bleak storm-swept island, and what were their arts? With a view to obtaining some answer to these interesting questions, careful exploration has been made of the shell-heaps of the Island, and the results of the work are embodied in this paper.

The first scientific notice of the Island appeared in 1840, in the State Geological Report of Rhode Island. Since then many discussions of its geological formations have been published, and chief among recent writers on this subject is Prof. Marsh of Yale University. His papers entitled "The Geology of Block Island" and "The Jurassic Formation on the Atlantic Coast," lately published in this Journal, have done much to remove the stumbling-block long offered by the basal clays of the islands off the New England coast. From the first of these papers (vol. ii, p. 297, 1896) is taken the following quotation, which was apparently the first notice of the Block Island shell-heaps to appear in any scientific publication:

"On some of the glacial hills near the shore, or around the Great Pond, shell-heaps of considerable antiquity may be observed, but so far as I could ascertain, none of them have been explored. One may be seen on the south side of the road recently cut through a low hill near the new steamboat landing on Great Pond. The deposits are several feet in thickness, indicating a long occupancy of the place by some of the early inhabitants of the island. The short examination I was able

* A Thesis presented for the degree of Ph.D. at Yale University, June 1, 1898.

to give this 'kitchen midden' disclosed many marine shells, mainly species now living in the adjacent waters, the most abundant of which were of oysters, clams, and scallops. Mingled with these were a few bones of fishes, birds, and small mammals."

The present writer takes this opportunity to express his personal obligation to Prof. Marsh, who thus called attention to the shell-heaps, and through whose courtesy a thorough exploration was made possible.

Geology.

Before commencing a description of the shell-heaps, it may be well to state briefly the geographical position of Block Island, and some of the theories concerning its general geological relation to the adjacent islands and the mainland. An outline map of this region is shown on Plate III.

That the same geological formations are found on the long series of islands reaching from New York to Martha's Vineyard, is the decision of geologists who have made a study of them. That the superficial stratum is of glacial origin is also agreed upon by all. Until recently, however, there has been a wide diversity of opinion as to the age of the basal clays that form the lowest visible beds of the series. Several authors have made passing reference to possible connections of certain of these islands with each other and with the mainland, but their discussions have been chiefly confined to geological periods far removed from the present day, while the geographic conditions during post-glacial time, which are of closer and keener interest to the zoologist, have been disregarded.

Prof. Marsh writes (this Journal, vol. ii, p. 295, October, 1896): "That Block Island was once connected with Long Island is suggested by a glance at a map of the New England coast, and that the same great moraine extended over both is evident from facts well known. An examination of Block Island itself, however, soon proved to me that these glacial deposits were merely a superficial covering, while the main body of the island was formed of much older beds, the exact age of which offers a most interesting problem." These beds, he states, are composed of variegated fresh-water clays similar to the plastic clays of Long Island and Martha's Vineyard. The indications are that they were deposited in the quiet waters of a basin which was formerly separated from the Atlantic Ocean by a great barrier that has since been destroyed by erosion and subsidence.

Prof. Shaler, in his "Report on the Geology of Martha's Vineyard" (Rept. U. S. G. S., p. 304, 1885–6), while treating of this series of islands, refers to the "considerable gap . . which divides Martha's Vineyard from Block Island." Continuing, he says: "The cause of this break is not perfectly

clear, but it is probably due, not to any failure of the glacial deposits to be formed in this space or in any considerable degree to their erosion, but rather, it is likely, to the fact that the floor on which they rest was originally lower in this part of the coast than elsewhere. This is indicated by the circumstance that from the western end of Martha's Vineyard there is a shoal that extends to Block Island and thence to Long Island. This shoal seems to be a continuation under water of the glacial mass to which Long Island and Martha's Vineyard belong." In the same report (p. 349), he expresses the belief that Martha's Vineyard has been connected with the mainland since the close of the glacial period, and adds that the animals and plants of the island are in no way peculiar, there being a few species existing on the mainland which are not found on the island, but none on the island which are altogether limited to it. He also makes the following statement: "We can hardly believe that several large-seeded plants and many of the land animals have found their way across the five miles of water which separates the Vineyard from the continent."

Turning to the United States coast charts, it will be seen that it is eight nautical miles from Block Island to the nearest part of the mainland, the maximum depth of water in the intervening channel being twenty-two fathoms. The straight course from Block Island to Montauk Point is twelve nautical miles, but here the soundings are far less than those taken in the waters to the north and east of the Island, doubtless because of extensive shoals formed by the tidal currents. These shoals stretch from the Island and from Montauk Point toward the middle of the intervening channel, at which point there is apparently a sudden increase in depth to between thirteen and sixteen fathoms. The character of the bottom over these shoals is hard, with occasional rocky localities. In fact, it is essentially the same as that of the bars underlying Plum Gut and the channels east and west of Great Gull Island.

In this Journal (vol. xl, No. 240), appeared an article by Prof. J. D. Dana entitled "Long Island Sound in the Quaternary Era, with Observations on the Submarine Hudson River Channel." The theories there set forth were the result of close inspection of soundings taken between the years 1878 and 1883. Apparently the author did not trace the former course of the Connecticut River with perfect confidence, for he took up and dismissed the subject in the following paragraph:

"As regards the existence of a submarine Connecticut channel the evidence referred to is certainly unsatisfactory. The bend in the bathymetric lines on the accompanying map be-

tween Montauk Point and Block Island looks right for such an origin, and strongly so. But considering the effects of tidal scour during the ebb through the narrow passages of the Sound, briefly referred to above, it is plain that the channel is of this kind. Block Island and Montauk Point stretch out under water far toward one another, and therefore the deepening from 12 fathoms to 27 and 30 over the narrow interval is a reasonable result for scour. The loops farther south in the bathymetric lines are too broad to be relied on for any conclusion . . . but tidal scour accounts well for the present condition of the region." The case briefly stated is this: In 1890, it was Prof. Dana's opinion that decisive evidence was wanting to prove that the original bed of the Connecticut River passed between Montauk Point and Block Island, for the tidal action, he said, was itself able to scour out such channels as were then supposed to lie on the north and south sides of the bar connecting the Island with Montauk Point.

Prof. Dana's bathymetric lines were plotted from soundings taken between 1878 and 1883, as has been already stated. It is a significant fact, and one to be carefully noted, that similar bathymetric lines, plotted from more complete and extended series of soundings, taken off Montauk Point in the years 1895 and 1896, show that the channel leading seaward from the bar is longer, deeper, and more pronounced now, than it appeared to be when Prof. Dana wrote that it "looked right" for a river-bed origin. The depression which then appeared to be a mile and a half long is now known to be ten miles long. It is not conceivable that this channel should have been enlarged to so great an extent by the ebbing tides during the past fifteen years; and the only conclusion possible is that this channel is the old Connecticut River bed, which Prof. Dana considered doubtful because soundings had not been thoroughly taken over the critical region.

The Shell-heaps.

Three shell-heaps of considerable size were explored by the writer during the year 1897. They will be mentioned in this paper under the names of the Fort Island Shell-heap, the Mott Shell-heap and the Cemetery Shell-heap. Their position is shown on Plate II. In addition to these, two very small deposits of shells, bones, etc., were discovered by systematic sounding in the immediate vicinity of the Cemetery Shell-heap, and a tract of land on the west bluff of the Island was found to contain numerous small deposits mainly composed of fish bones. There is no reason for supposing that these are all the shell-heaps formed during the occupancy of Block Island by the Manissees or their predecessors. On the contrary, it is quite possible that other deposits are still con-

cealed beneath the surface of some of the grassy hillsides draining into the fresh-water ponds. Moreover, the shifting sand-dunes now overlying much of the narrow parts of the Island on the east and west sides of the Great Salt Pond may, at some future time, uncover the sites of abandoned Indian villages. Shell-heaps may again be exposed when roads are constructed or repaired, and a careful search through the ploughed fields would undoubtedly yield a rich harvest of stone arrow-points and spear-heads.

The Fort Island Shell-heap.

The Fort Island Shell-heap originally covered the center and highest part of the island, which is situated near the middle of the small but deep Trim's Pond, now emptying into the Great Salt Pond. The indications are that at one time this shell-heap consisted of a circular deposit about fifty-five feet in diameter and two feet or more in depth at the center, the layer of shells, etc., thinning gradually toward the margin.

About ten years ago, in constructing the "New Road" from the Old Harbor to the Great Salt Pond, a cut several feet deep was made in a northwesterly direction across the middle of this shell-heap, and the thrifty workmen used the excavated material for filling in the pond where the road should cross it on each side of the island. If any confidence can be placed in the account given by the laborers who were engaged in the work, it would seem that archeological specimens of great value were thus destroyed or lost.

In April, 1897, the greater portion of what then remained was explored. The deposit on the northeast side of the cut was of small extent, and proved of little interest beyond marking the boundary of the original heap. It was a layer having an extreme depth of six inches, and composed of a black soil in which were scattered a few shells and bone fragments. On the southwest side of the cut was exposed a section of the shell-heap fifty feet long and about eighteen inches deep at the middle of the section, from which point the depth gradually diminished toward the margin in both directions. Near the middle of the section the layer was composed principally of shells mingled with bone fragments, the color of the mass being darkened by the intermixture of a fine black soil. Toward the northwest, the color of the layer became darker, and more fragments of bone were to be seen in proportion to the number of shells, the margin of the shell-heap showing a plentiful deposit of bones but no shells. At the other end of the section, the layer was composed almost entirely of shells and consequently was nearly white. When first seen from a little distance, the layer appeared to have twice its actual

depth, owing to the fragments of bone and shell which the rain had washed down from their original position near the top of the cut. The deposit was everywhere covered by a foot or more of poor soil under cultivation, which, strangely enough, yielded no surface specimens.

At this time, the road crossing Fort Island was being graded and hardened by the State of Rhode Island, and the engineer in charge obligingly detailed some of his workmen to grade the sides of the cut under the writer's direction, thus making it possible to save many specimens of value. Subsequently permission was obtained from the owner of the land on the southwest side of the cut, to explore that part of the deposit which lay beyond the boundary of the roadway, and much additional material was collected.

The following list gives the species of animals whose remains were found in this shell-heap, and also the names of the various manufactured articles:

Mammalia.

Homo sapiens (Man).
Cervus virginianus (Virginia Deer).
Canis familiaris (Dog).
Ursus americanus (Black Bear).
Lutra canadensis (Canada Otter).
Phoca vitulina (Harbor Seal).
Globiocephalus melas (Blackfish Whale).

Aves.

Corvus frugivorus (Crow).
Halietus leucocephalus (Bald Eagle).
Grus canadensis (Northern Brown Crane).
Bernicla canadensis (Canada Goose).
Fulix marila (Broad-bill).
Mergus serrator (Red-breasted Merganser).
Mergus merganser (Merganser).
Phalacrocorax dilophus (Double-crested Cormorant).
Larus argentatus (Herring Gull).
Colymbus torquatus (Common Loon).

Reptilia.

Chelydra serpentina (Snapping Turtle).

Pisces.

Gadus morrhua (Cod).
Centropristis striatus (Black Sea Bass).
Temnodon saltator (Blue-fish).
Lophius americanus (Angler).
Acipenser sturio (Sturgeon).

Mollusca.

Ostrea virginiana (Oyster).
Pecten irradians (Scallop).
Mya arenaria (Long Clam).
Venus mercenaria (Quahog).
Crepidula fornicata (Boat-shell).
Mytilus edulis (Mussel).
Modiola plicatula (Mussel).
Nassa obsoleta (Black Sea-snail).
Helix alternata (Land-snail).

Crustacea.

Balanus tintinnabulum (Barnacle).

Implements.

(Stone.)

Axe.
Spear-heads.
Arrow-points.
Knives.

(Bone.)

Bodkin.
Worked pieces of unknown use.

Pottery.

The Mott Shell-heap.

The other shell-heaps and smaller deposits to be described in this paper were explored during the month of July, 1897. The second shell-heap explored will be designated as the Mott Shell-heap, as it was situated on the northwest side of the lane which passes S. D. Mott's dwelling-house and a few rods from the "New Road." Fragments of shells cropping out at the roadside called attention to the presence of this shell-heap, which ultimately proved richer in vertebrate remains than any of the other deposits. Evidently a portion of this shell-heap, too, had been destroyed in road-making, for the horizontal plane of the layer was nearly semicircular with the straight side bordering on the lane. The greatest diameter of the layer was twenty-one feet, the least diameter about nine feet, and the depth a little over two feet. The shell-heap was covered by about ten inches of soil overgrown by a rich turf. The deposit consisted mainly of oyster and clam shells packed closely in the characteristic black soil, but in addition to these were found the remains of many species of mammals, birds, fishes, and reptiles, as well as numerous implements of stone and bone and bits of pottery. A careful examination of this shell-heap brought to light much valuable material, as will be seen by a glance at the following list:

Mammalia.

Cervus virginianus (Virginia Deer).
Canis familiaris (Dog).
Lutra canadensis (Canada Otter).
Phoca vitulina (Harbor Seal).
Phoca groenlandica (Harp Seal).
Halichoerus grypus (Gray Seal).
Globiocephalus melas (Black-fish Whale).
Castor canadensis (Beaver).

Aves.

Corvus frugivorus (Crow).
Bubo virginianus (Great Horned Owl).
Buteo lineatus (Red-shouldered Hawk).
Halietus leucocephalus (Bald Eagle).
Grus canadensis (Northern Brown Crane).
Bernicla canadensis (Canada Goose).
Fulix marila (Broad-bill).
Fulix ferina (Red-head).
Mergus serrator (Red-breasted Merganser).
Mergus merganser (Merganser).
Querquedula carolinensis (Green-winged Teal).
Oidemia fusca (Coot).
Phalacrocorax dilophus (Double-crested Cormorant).
Larus glaucus (Ice Gull).
Larus argentatus (Herring Gull).
Colymbus torquatus (Common Loon).
Colymbus septentrionalis (Red-breasted Loon).
Podiceps griseigena (Red-necked Grebe).
Alca impennis (Great Auk).
Utamanea torda (Razor-billed Auk).

Reptilia.

Chelydra serpentina (Snapping-turtle).
Terrapene carolina (Box Tortoise).
Chrysemys picta (Painted Tortoise).

Pisces.

Gadus morrhua (Cod).
Labrus tautoga (Tautog).
Centropristis striatus (Black Sea Bass).
Roccus lineatus (Striped Bass).
Lophius americanus (Angler).
Lamna punctata (Mackerel Shark)
Acipenser sturio (Sturgeon).

Mollusca.

Ostrea virginiana (Oyster).
Pecten irradians (Scallop).
Mya arenaria (Long Clam).
Venus mercenaria (Quahog).
Crepidula fornicata (Boat-shell).
Modiola plicatula (Mussel).
Mytilus edulis (Mussel).
Nassa obsoleta (Black Sea-snail).
Helix alternata (Land-snail).

Crustacea.

Balanus tintinnabulum (Barnacle).

Implements.

(Stone.)

Axes.
Disc.
Knives.
Spear-heads.
Arrow-points.

(Bone.)

Bodkins.

Pottery.

The Cemetery Shell-heap.

About an eighth of a mile south of the Great Salt Pond, and a few rods northeast of the cemetery, shells, bones, implements, and pottery were found together in a layer, which nowhere exceeded ten inches in depth, but was spread irregularly over an area of about seven hundred square feet. Because of its situation, it will be referred to as the Cemetery Shell-heap. The border of the deposit at the roadside had been broken up by ploughing, and at the time of exploration lay bare, while the rest was hidden by a few inches of soil which bore a strong turf. The list of the animal remains and implements obtained from this deposit is given below, and will be found to contain two vertebrate species not in the preceding lists.

Mammalia.

Homo sapiens (Man).
Canis familiaris (Dog).
Phoca vitulina (Harbor Seal).
Phoca groenlandica (Harp Seal).
Cervus virginianus (Virginia Deer).
Arvicola riparia (Meadow Mouse).

Aves.

Cygnus columbianus (American Swan).
Grus canadensis (Northern Brown Crane).
Fulix marila (Broad-bill).
Mergus serrator (Red-breasted Merganser).
Oidemia fusca (Coot).
Querquedula carolinensis (Green-winged Teal).

Pisces.

Lophius americanus (Angler).
Lamna punctata (Mackerel Shark)
Acipenser sturio (Sturgeon).

Mollusca.

Ostrea virginiana (Oyster).
Pecten irradians (Scallop).
Mya arenaria (Long Clam).
Venus mercenaria (Quahog).
Crepidula fornicata (Boat-shell).
Mytilus edulis (Mussel).
Modiola plicatula (Mussel).
Helix alternata (Land-snail).

Crustacea.

Balanus tintinnabulum (Barnacle).

Implements.

(Stone.)

Knives.
Spear-heads.

(Bone.)

Fish-hook.

Pottery.

Other Localities.

About an eighth of a mile south of the Cemetery Shell-heap, a thin deposit was discovered under the turf at the roadside. It covered an area of only fifteen or sixteen square feet, and yielded few specimens of interest. From it were taken fragments of pottery and the remains of the following species of animals:

Phoca vitulina (Harbor Seal).
Acipenser sturio (Sturgeon).
Terrapene carolina (Box Tortoise).
Ostrea virginiana (Oyster).
Venus mercenaria (Quahog).
Mya arenaria (Long Clam).
Mytilus edulis (Mussel).

A second small deposit, similar to that last described, was found at the side of the lane immediately south of the cemetery. It contained fragments of pottery and the remains of four species of animals, viz:

Lamna punctata (Mackerel Shark)
Mya arenaria (Long Clam).
Pecten irradians (Scallop).
Helix alternata (Land-snail).

The west bluff of the Island between Grace's Point and the Gut is covered for the most part with sand dunes, some of them grassed over, others unprotected and probably still being drifted by the gales which sweep the Island. Those which are protected by grass may possibly have retained their form and position on the bluff for many years. This much at least is certain: in many places under their surface, at depths varying from a few inches to a foot and a half, small deposits of shells and bones were found. With these animal remains were fragments of pottery and a few stone scrapers or knives as well as many refuse flakes of quartz and quartzite. From this locality the following species were obtained:

Cervus virginianus (Virginia Deer).
Phoca vitulina (Harbor Seal).
Grus canadensis (Northern Brown Crane).
Podiceps griseigena (Red-necked Grebe).
Temnodon saltator (Bluefish).
Acipenser sturio (Sturgeon).
Venus mercenaria (Quahog).
Mya arenaria (Long Clam).

On the accompanying map of Block Island (Pl. II) the positions of the shell-heaps and deposits are marked thus *. As may be seen, they are without exception placed close to the Great Salt Pond, where the Indians probably obtained most of the bivalves used for food. The mussels, however, which they consumed in large quantities, were no doubt gathered from the rocks lying awash off the sea-beaches of the Island. The problem of existence must have been simple for the Manissees when they were not at war with the Montauks and Narragansetts, for they apparently had an abundance of shell-fish in the Great Salt Pond within bowshot of their villages, and a plentiful supply of fresh water in the ponds which are to be seen in nearly all the clay-lined basins throughout the Island.

Age of the Shell-heaps.

In many places along the Atlantic coast of North America, indications as to the age of shell-heaps explored have been furnished by the overlying forest mould and by large trees of slow growth whose roots have forced their way through the deposits. Block Island, now denuded of its wealth of forest trees, affords no such evidence of the age of its shell-heaps, and reliance must be placed upon those indications which are obtainable from the contents of the deposits themselves and from the few existing references to the early history of the Island. In 1636, the Massachusetts Bay Colony, in revenge for the murder of John Oldham by the Manissees, sent an armed expedition under the command of Capt. John Endicott to make conquest of Block Island. This was accordingly done to the extent of killing fourteen Indians and maiming others, killing several dogs, burning many deserted wigwams and "great heaps of pleasant corn ready shelled," and carrying away "many well-wrought mats and several delightful baskets." From the records of the Massachusetts Bay Colony, under date of October 19, 1658, the following extract is made:

"This Court, in consideration of the honnored Gouernor, Jno. Endicott, Esq, his great services to this country, together with the good services of Rich Bellingham Esq, Dept Gouernor, and in respect of Major Gen Daniell Dennison, his great paynes in transcribing the lawes, & in regard of Major

Wm Hawthornes surrendring his seven hundred acres of land formerly graunted to him, doe relinquish theire clayme, & do graunt all their right & interest that this Court haue or might haue in Block Island to the above mentioned fower gentn, to each of them a quarter parte." In 1660, these four gentlemen sold their title to the Island to a company of sixteen men who took possession early in the following year; and from that time on the Island was controlled by the English. The presence in the shell-heaps of a variety of primitive implements of stone and bone, as well as refuse flakes of quartz, and the absence of all fragments of metal or European earthenware, make it obvious that these shell-heaps were formed before the colonization of the Island by the English. How long before that event the oldest deposits were laid down is purely conjectural.

Condition of the Vertebrate Remains.

The vertebrate remains found in the different shell-heaps and smaller deposits were damp when first removed, owing to their proximity to the surface and to the frequent and heavy rains which fell during the time of exploration. With the exception of fragments of the larger bones of the deer, which had resisted the action of frost and moisture to some extent, they were soft and liable to crumble in spite of great care taken in removing and preserving them. They were wrapped in cotton and allowed to dry slowly for several weeks. At the end of that time, they were found to be dry, light, and very brittle, and the readiness with which they absorbed moisture from the tongue or wetted finger showed that, during a long period of underground weathering, they had lost much of their organic composition. Very few of the bones were perfect. The shafts of the limb bones of the deer and dogs had been broken for the marrow they contained, though no pains had been taken to split them lengthwise. The articular ends of the long bones of the bird skeletons were often missing from the shafts, and in some cases marks of teeth were visible where these softer parts had been gnawed away, probably by dogs. A few of the bone fragments were charred, and a large proportion of the rest had been darkened to some extent by exposure to fire.

The Great Auk.

The fact that the bones of the Great Auk were found in two shell-heaps, viz., the Mott Shell-heap and the Cemetery Shell-heap, is of interest, since it adds to the knowledge of the distribution of this extinct bird. In an article by Mr. Frederic A. Lucas entitled "The Great Auk" (Rept. Nat. Mus., 1889),

a chart is given showing the localities in which remains of the Great Auk have been found in Indian shell-heaps. Although Mr. Lucas gives no locality south of Cape Cod, he says that this bird was probably common along the New England coast. So far as the writer can learn, the only evidence of its presence south of Cape Cod is to be found in Brereton's "Account of the Voyage of Gosnold to Virginia," where mention is made of "penguins" in the list of birds of the country. The date of Gosnold's arrival in Virginia was April 26, 1607.

A theory has been advanced by Fannie P. Hardy (The Auk, July, 1888) that the New England shell-heaps were formed principally during the summer encampment of the Indians at the shore, and that the finding of auk bones throughout the deposits points to the presence of these birds on the coast during their breeding season. In regard to the Block Island shell-heaps, there is no reason for supposing that they were deposited during the summer only, or even principally. On the contrary, the remains of many birds which visit our coast in the autumn and early spring rather indicate a permanent residence of the Indians there. Furthermore, the fact that all the auk bones found belonged to mature skeletons is opposed to the theory that these birds bred on the island.

The Gray Seal.

While exploring the Mott Shell-heap, part of a skull of the Gray Seal (Halichoerus grypus) was discovered. This consisted of a left maxillary and its premaxillary, with a nearly complete series of the teeth borne by these bones. A few small fragments and phalanges were found near the imperfect skull, and probably belonged to the same skeleton, although they have not been identified with certainty. The teeth in place were the second and third incisors, the canine, and the five teeth of the premolar and molar series. This seal had evidently reached an extreme old age, for all the teeth were much worn, especially the incisors and canine, which had been ground down until their pulp cavities were exposed to view. Only one individual of this rare species of seal was obtained from the Block Island shell-heaps, and there is no reason to suppose that it frequented the waters around the Island in such numbers as did the Harbor and Harp Seals. Yet its occurrence here is of interest when what has been written about its distribution is taken into consideration. From J. A. Allen's "Monograph of the North American Pinnipeds," the following quotation is made: "The Gray Seal appears to be not only one of the least abundant of the northern Phocids, but also to be restricted to a rather narrow range. It is wholly confined to

the North Atlantic, and even here is found within comparatively narrow limits. On the American coast, it occurs as far southward as Sable Island, Nova Scotia, where its presence is attested by specimens in the National Museum, collected there by Mr. P. S. Dodd. This, however, is the southernmost point at which it is known to occur."

Great Salt Pond.

The large size of the oyster- and other shells in the deposits is worthy of note. Oyster-shells measuring seven inches long and of ordinary proportions were of common occurrence in the deposits, and most of the clams and scallops also were well grown. Barnacles three-quarters of an inch in diameter were found in the shell-heaps. These had evidently been brought from the pond, attached to scallops, for the bases of the barnacles showed the imprint of the scallop-shells they had grown upon. From the earliest time of which tradition speaks, the Great Salt Pond yielded an abundant supply of oysters, clams and scallops, which leads to the supposition that it was more or less open to tidal flow. But about twenty years ago, the breach had apparently filled up, for at that time the last boatload of oysters was shipped from the Island.

In the "Fisheries of the U. S.," 1887, is found the following statement: "A narrow roadway that is often overflowed separates this pond from the sea. By many this pond is supposed to be sustained by springs flowing from the surrounding hills; others claim that it is supplied from the ocean by the water filtering through the narrow beach, and that its brackishness is caused by a partial evaporation of the salt. Enough salt is retained from this cause, as well as from the overflow from high tides and storms to sustain oysters and other shell-fish up to about half growth, at which time they die. A breach through the beach into the sea is much needed, and this question is now agitated by the inhabitants. With a small outlay thousands of bushels of fine oysters could be made to add to the yearly income of the fisheries."

Recently a deep "gut" has been dredged through the narrow beach on the west side of the Great Salt Pond, in order to make a harbor for medium-draught vessels, and the supply of fresh water from the springs at the shore of the pond is so small comparatively, that the water of the harbor is now practically as salt as the pure sea water. It remains to be seen whether the oyster fishery, which was one of the chief means of support of the prehistoric inhabitants of the Island, will be revived by the Block Islanders of the present day.

Distribution of the Fauna.

With the exception of the Great Auk and the Gray Seal, the vertebrate animals whose remains have been found in the shell-heaps were probably of common occurrence along the southern New England coast at the time of the coming of the English. Many of the species of birds now pass in their annual migrations to and from their breeding-places in the north, and a few are known to breed in this part of the country. That great numbers of edible sea-fowl should have been taken by the Indians is nowise remarkable, for the fresh-water and brackish ponds scattered over the Island must have been attractive feeding-places for these birds. The reptiles and fishes are all to be found in this latitude as well as in other localities farther north and south; and there is little indication that the shell-heaps date back to a remote period when a colder climate prevailed. The finding of many individuals of the species of Harp Seal and Gray Seal might be considered evidence of a sea-temperature lower than that of the present time, but such an inference can hardly be drawn from the discovery of the remains of only three Harp Seals and one Gray Seal.

During the time spent in exploring the shell-heaps, the writer's attention was attracted by the batrachians and reptiles which are now plentiful on the Island. Two species of tortoises were found, *Chrysemys picta* and *Cheldra serpentina;* and also two species of snakes, which were probably *Bascanium constrictor* and *Eutaenia sirtalis.* Capt. Uriah B. Dodge, the Harbor Master of Block Island, has taken a kindly interest in the present investigation. In reply to a letter asking what species of reptiles he had observed on the Island, he writes: "As to snakes, there are a few garter snakes and water snakes. One or two black snakes have been seen.

"There are plenty of pond turtles—green ones, and some big snapping turtles. Very large sea turtles are caught occasionally."

It is possible that the pond turtles may have been brought to the Island and there liberated, or that they may have been driven across from the mainland by heavy northerly gales. But in the case of the snakes, now represented on the Island by at least three species, the probabilities are decidedly against the theory of artificial introduction either by the white settlers or by the Indians. Although Capt. Dodge does not mention the common box tortoise in his letter and the writer has not seen it alive on the Island, yet abundant remains of this species were obtained from two shell-heaps. As it is probable that the tortoises now found on the Island are of the same stock as those taken by the Indians, any theory that explains the occur-

rence of the modern Chelonidæ can be applied equally well to those of prehistoric times. Similar problems of distribution arise in the case of the land mammals represented in the shell-heap collections. Like the reptiles, they may possibly have been transported by natural or human agency, or some of them may have traveled there on the ice just before the final retreat of the great glacier; but their occurrence may be explained in a simpler and more satisfactory way which will not antagonize the accepted theories concerning the recent geology of the New England coast and the distribution of its fauna. In order to do this, it will be necessary to ascertain what surface conditions prevailed on the Island until about two hundred and fifty years ago, and also to consider some evidences of change in level during the recent period.

Mr. Livermore's "History of Block Island" contains an interesting chapter on "Peat and Timber," giving many valuable references to the forest trees of the Island. Mr. Livermore writes that "a heavy growth of timber covered much of the surface of the Island at the time of its settlement;" and that "the kinds of timber most common here were oak, elm, pine, hickory, ash and cedar, with a thick growth of alders in swampy places, which were small and numerous." In regard to the peat deposits the same author states that "the beds are also numerous, and in every part of the Island. Some cover several acres, and others are much smaller. Some are shallow, and others are deep, and most of them were formed by vegetable matter, leaves, bark, nuts, grass, ferns, decayed wood, etc., that for ages had been washed down the surrounding steep little hillsides. Thus peat beds were deposited upon some of the highest parts of the Island, as upon Clay Head, and the supply was ample, if not exhaustless." Mr. Livermore makes this statement also: "In the peat deposits roots and trunks of large trees are frequently discovered."

From the foregoing quotations, it is evident that, long before the Island was discovered by Europeans, it bore a rich growth of those species of forest trees which are now found on the mainland; and the peat deposits imply the former existence of many ponds and swamps scattered over its forest-clad surface. With the destruction of the trees and the constant diminution of the Island itself, owing to the erosion of its shore, the number and size of the fresh-water ponds have become less, and consequently many of the springs on the hillsides have failed. Still, even now, the supply of water would be sufficient for the support of many kinds of wild animals.

Evidence of the old Connecticut River channel between Block Island and Montauk Point has been already referred to in this paper. Attention is now called to the fact, obvious

though it is, that a river bed implies the existence of land on both sides to form the banks, and therefore it seems probable that at the time when the Connecticut River was scouring out its deep channel across the continental margin, there was a land connection of Block Island with the mainland. Just when the destruction of this land connection could have taken place is not clear; but some light upon this important question may be obtained from the evidence that at a comparatively recent time Block Island has undergone a submergence of several feet.

In a paper entitled "On Pleistocene Changes of Level in Eastern North America," by Baron Gerard De Geer (Proc. Boston Soc. Nat. Hist., 1892), is to be found much information regarding submergence along the southern New England coast. After reviewing the condition of the west shore of New Haven harbor, the writer says: "These facts seem to be in accordance with the assumption that this coast is slowly sinking, and I failed to find any proofs that since the ice age the land was ever more deeply submerged than it is now." Of Martha's Vineyard, De Geer makes this statement: "On Martha's Vineyard, where I had the advantage of Prof. N. S. Shaler's guidance, I could only confirm his observation that no raised beaches of any kind were to be seen."

Block Island nowhere exhibits raised sea-beaches indicating recent emergence; but, on the contrary, in certain places, former pond bottoms are exposed in the shelving bluffs only a few feet above the level of high tide, and according to Mr. Livermore, from whose history several quotations have already been made, "three [peat] beds of considerable known size, that may be larger than known to be, one on the east side of the Island, and two on the west, extend a considerable distance from the shore into the ocean." No specimens of peat from these beds are obtainable for examination at this time of writing; yet, judging from their description, they present many points of similarity to the submarine peat beds of Nantucket, of which Prof. Shaler, in concluding his discussion of the fossiliferous deposits of Nantucket (Geol. of Nantucket, 1889), writes: "So far as I am informed this is perhaps the clearest evidence which has been obtained showing recent subsidence along this part of the New England coast. As to the date of the subsidence no evidence seems obtainable from this locality. The peaty matter has a very fresh and unconsolidated aspect. The roots of the rushes which it contains are singularly recent looking; they are little decayed, and indeed seem to retain some part of their color and odor."

The eastern part of Long Island is being slowly submerged, for similar peat-beds below high water mark are also reported

from Montauk Point. Dr. Hollick of Columbia University, referring to the phenomena of submergence and erosion, says (Trans. N. Y. Acad. Sci., xvi, p. 17, Dec. 15, 1896): "Should they continue in the future it requires but little prevision to appreciate that Block Island and the islands to the eastward will continue to shrink in size, disappear, and eventually form merely parts of the shoals which now connect and surround them. Montauk Point will continue to recede, and, by the submergence of the low narrow strip of land in the vicinity of Canoe Place, a new island will be formed from what remains of the Point."

In view of this clear evidence of the sinking of the chain of islands lying off the southern New England coast, it appears possible that the land connection of Block Island with the mainland was raised above the sea-level at the close of the Glacial Period, and was not again submerged until some time during the Recent Period when the fauna of the New England region was essentially the same as it is now. There would then have been an opportunity for the distribution of the animals of the mainland over a large peninsula which is now represented by the rapidly dwindling Block Island.

The dogs, no doubt, were originally brought from the mainland by their masters, and therefore must be excepted from any conclusions which may be reached in regard to the indigenous fauna of the Island. But, as has been shown, the surface condition of Block Island when settled by the English was such that there is no reason why all other animals named in the foregoing lists could not have been supported. Moreover, it is unlikely that the Manissees, a tribe frequently at war with their neighbors, the Narragansetts and Montauks, would have carried quantities of fresh meat from the mainland in their canoes, when their own country and its surrounding waters supplied them with an abundance of fish, shell-fish and sea-fowl.

This hypothesis is certainly well borne out by the rich growth of forest timber once covering the Island, and, in the opinion of the present writer, it offers the best solution of the problem of distribution arising from the presence of the remains of land animals in the prehistoric shell-heaps.

Archeological and Ethnological.

There are several topics connected with the description of the Block Island shell-heaps which deserve notice here, although they are quite apart from the discussion of the fauna. One of these, the discovery of human remains under peculiar circumstances, is of especial interest.

Human Remains.

Just within the western margin of the Fort Island Shell-heap and about a foot below the surface of the ground, a human skull was exposed. It was found impossible to remove the skull intact; so after carefully scraping and brushing away the surrounding earth, an examination was made before lifting it from its bed in the ground. The greater part of the brain-case was apparently uninjured, but the lower part of the parietal region of the left side was fractured and crushed. The lower jaw was complete and in place.

The dentition of the jaws is that of a child of about seven and a half years of age. Although the enamel has been much worn from the crowns of the deciduous teeth, exposing large tracts of dentine, there are no cavities caused by decay. The crowns of the canines are ground to flat surfaces, but it is impossible to ascertain the character of the edges of the incisors, whether worn by cutting or grinding, as the deciduous incisors have been shed and none of their successors are sufficiently advanced to show any marks of wear. The skull is now in fragments that cannot be assembled; but when first examined before removal from the ground, it showed little variation from the average type of skull of the New England Indians.

Excavating in the direction indicated by the position of the skull, remains of vertebræ and ribs were next uncovered, though their condition at the time of burial could not be ascertained, as they were poorly preserved. Of the vertebral series, only the axis and part of the atlas were successfully removed. A portion of the left scapula was saved, while the right scapula was so decomposed that removal was impossible. None of the bones of the hands and arms were found. Most of the pelvis was removed, though not without injury, owing to its brittle condition. The right femur was in place and entire, but not the slightest trace was found of the rest of the limb. The bones of the left leg were in place and were complete down to a point two or three inches above the lower articular ends of the tibia and fibula. These articular ends were wanting, as were also the bones of the foot, though it is to be noted that, at the margin of the shell-heap and about seven feet from the rest of the skeleton, a left astragalus was found, poorly preserved and of such size that it might well have been part of this skeleton. The fractured ends of the tibia and fibula had weathered to the same hue as the natural surfaces of the bones.

The skeleton throughout was in a poor state of preservation, the bones became very light and brittle after drying slowly in cotton-batting, and their peculiar feeling, when touched by the tongue, gave evidence of long underground weathering.

The only limb bones which afforded measurements were the two femurs; their lengths were found to be eleven and a quarter inches, indicating a total stature of about forty-two inches. A careful search brought to light no other human bones from this shell-heap.

Cannibalism.

The discovery of this skeleton is of especial interest to the archeologist, inasmuch as it throws light on the subject of the prevalence of cannibalism among the Indians of the New England coast. That the child whose skeleton has just been described met with a violent death was suggested by the defective condition of the left wall of the skull, though whether a blow causing such a fracture was given in the act of capture or as a coup-de-grace would be fruitless to discuss. Further, the fact that the skeleton had been apparently cast upon the heap of shells, bones, wood ashes, and broken cooking utensils, is suspicious, and does not indicate the slightest degree of that reverent care usually observed in the Indian funeral ceremony. The absence of the arms and of portions of the lower limbs can best be accounted for by supposing them to have been cut off for greater facility in cooking. The places of amputation point to a crude knowledge of anatomy, for the shoulder and knee joints are those which a savage could best divide with his rough stone knife, and after failing to master the nicety of the ankle joint, he might be tempted to try a few inches higher up, at the small of the leg, where he would at least be unhindered by any complex articulation.

An ingenious theory has been advanced to account for the finding of this human skeleton in a shell-heap. Believing that it has not appeared before, the writer states it here briefly. When a death occurred during the cold winter months, it would have been difficult for the Indians, provided only with rude mattocks of stone or wood, to dig a grave in the frozen ground; yet under their fires, which were probably located within the limits of their shell-heaps or at least close to them, there would have been little or no frost in the ground, and a grave could have been dug with comparative ease. This theory might account for the occurrence of a complete skeleton in a shell-heap, but it fails to satisfy the requirements of the present case, where a skeleton lacking the bones of arms and legs was found.

In the Cemetery Shell-heap, a piece of human skull was discovered consisting of parts of the frontal and left parietal bones. Judging from the development of the coronal suture, the fragment belonged to the skull of a fully mature individual. Although this is of less interest than the discovery of the child's skeleton in the Mott Shell-heap, it certainly adds somewhat to the evidence upon the subject under consideration.

Referring again to the murder of John Oldham by the Manissees, in 1636, the condition of Oldham's body when found may be particularly noted. Governor Winthrop describes the reprisal of the trader's sloop by John Gallop, and writes "and looking about, they found John Oldham under an old seine, stark naked, his head cleft to the brains, and his hand and legs cut as if they had been cutting them off, and yet warm." The reason for this attempted dismemberment of Oldham's corpse is readily understood if we accept the theory of cannibalism.

Stone Implements.

Stone implements are frequently found on the surface of the Island, though until this time little attention has been given them and few have been saved. Throughout the mass of each shell-heap, stone arrow-points, spear-heads, and knives or scrapers were found, nearly all of them made of quartz or quartzite, which are common bowlder materials. Besides these finished implements, there were quantities of irregular flakes showing some evidence of chipping. From the Fort Island Shell-heap, one roughly-made quartzite axe was taken; and from the Mott Shell-heap two large single-grooved axes, one of quartzite, and the other of a dark fine-grained porphyry; both of these had been carefully ground to sharp-cutting edges. Although a few well-made arrow-points of graceful shape were found, the average grade of workmanship shown by the shell-heap implements is much inferior to that displayed by the stone implements of the mainland. Indeed this lack of skill is sometimes manifest in the choice of material as well as in manufacture, for arrow-points were occasionally made of a dark gray argillite whose strong cleavage did not permit a good edge to be obtained by secondary chipping.

On the high wind-swept bluff near Grace's Point, an interesting discovery was made. The surface near the edge of the bluff is almost denuded of vegetation, and the finer grains of sand in the drift stratum are carried away by the wind as soon as they are exposed. Consequently the surface at this place is composed principally of glacial pebbles and coarse gravel. Many of the pebbles are of a fine quality of quartz or quartzite, well suited for the manufacture of the smaller stone implements. Here, within an area of about eight hundred square feet, was found a great number of worked stone pieces ranging through several stages of development from the simplest flakes to the finished arrow-points. Two of these are beautifully worked points of the tanged and leaf-shaped types which bear witness to far higher skill than do the implements

from the shell-heaps. This place was probably the site of an Indian workshop. So little has Block Island been explored, that these relics have remained for several years exposed to view at the top of the bluff. It seems likely, however, that for two centuries or more sand dunes have covered this part of the west shore of the Island. Another result of the drifting sand was shown at Crescent Beach, where an arrow-point was dug from the top of the glacial stratum which was overlaid by eighteen inches of black forest mould and five feet of drifted sand.

Implements of Bone.

In strong contrast with the crudeness of most of the stone implements is the finished character of the bone articles obtained from the shell-heaps. Three bodkins of deer bone were found. One of a slender willow-leaf form, about three inches long and half an inch wide, is ground to a sharp tapering point at one end, and at the other end bears a second smaller point protected in a clever way by a shoulder, so that a small hole could have been quickly made in a skin without the least danger of injuring or disfiguring the work. Another bodkin is about four inches long, and, except as regards its length, resembles a modern bone knitting needle. It is made from one of the long bones of a deer's skeleton. The shaft, which is nearly straight, has been carefully rounded and ground to a sharp point at one end, while the other end has been merely smoothed into the form of a rounded knob which may be rested against the palm of the hand.

Two peculiar bone articles whose use it would be hard to determine were taken from the Fort Island Shell-heap. One may have served as a scraper for dressing skins, for it is about three inches long and a little over an inch wide, and a sharp beveled edge has been ground upon one end. It is made from the right ulna of the American Black Bear. The other article is a piece of the left humerus of the same species of bear about two inches long and an inch wide, carefully ground to flat surfaces at the artificial sides and ends. It is remarkable that the Manissees, who were expert fishermen, should have left hardly a trace of their fishing-gear in the shell-heaps. One U-shaped bone object, which may be a broken hook, was taken from the Cemetery Shell-heap, but no entire hooks were found. Although the Block Islanders say that stone sinkers are occasionally picked up near the shore of the Great Salt Pond, none have been saved.

Ancient Pottery.

Broken pottery was taken from nearly all the shell-heaps and deposits explored, the yield of the Fort Island and Mott Shell-heaps being especially large. No attempt has been made to assemble the broken pieces, comparatively few of which are large enough to indicate the shape of the original vessels. But, so far as may be judged from these fragments, the ordinary form of pot had a rounded bottom and curving sides which were drawn in at the rim. A few were given an exceedingly graceful shape by letting the rim flare a little. The thickness of the fragments is from three-eighths to seven-eighths of an inch, and the largest pot had a diameter of fifteen inches. The material is apparently a mixture of clay with a small proportion of gravel and pounded oyster shells to make it fire better. The color of the pottery, when not hidden by a thick coating inside and out of soot and decomposed organic matter, is a dull red. It is evident from the grooves on the inside of many of the fragments that the potters frequently made use of large scallop shells which, owing to their bulging form, made excellent finishing tools. The grooves thus traced are very ornamental. That a pot finished in this manner could not be easily cleansed was probably thought of little importance.

A few fragments bear nearly obliterated lines outside, which resemble to a slight degree the impression of cords, but there is no certain evidence that any pottery was made in basket moulds. On the outside, ornamentation was often produced by scoring the pots with a toothed graining instrument. The result is especially pleasing to the eye when the lines traverse the pot obliquely. In some instances, the pots were first made smooth inside and out, and then some simple decorative designs were traced around the rims. One of the simplest designs consists of a triple girdle of dotted lines. Most of the vessels were pierced in three or four places for the passage of supporting cords, and on a few, the intervals between these holes have been marked by series of blind holes. Perhaps the most elaborate decoration is borne by a potsherd, which has its flaring rim ornamented with an oblique indentation. Around the narrowest part of the pot, an inch below the rim, runs a double girdle of dotted lines, close beneath which the holes for support are pierced, and these holes are surrounded by a fanciful fret design of dotted lines. In its form and decoration, this fragment shows that much taste and skill were exercised by the potter.

Conclusion.

Such is the brief account of the exploration of the prehistoric shell-heaps of Block Island, together with a statement of their contents, which were found to include a great variety of primitive implements and the remains of many species of vertebrate and invertebrate animals. The bones of the land animals seem at first to be strangely out of place upon a small island several miles out at sea; and the necessity is immediately felt for some explanation of their occurrence there. In view of the number of modifying factors which must have affected the distribution of the fauna over this interesting region, it is difficult to formulate a theory which shall satisfactorily explain the way in which the land animals came there. Still, in many cases, it is possible to arrive at conclusions which are supported by the weight of strong probability, and certainly all the known conditions of the problem are satisfied by the hypothesis which has been advanced; namely, that the area of land now represented by Block Island already possessed a considerable "mainland fauna" at the time of its separation from the continent. Whether this supposition is correct or not may be determined by future investigation; and it is to be hoped that this will lead to further discoveries tending to throw light upon this subject, as well as upon questions connected with the history of the Indian tribe which the English colonists supplanted.

Yale University, New Haven, Conn., June 1, 1898.

EXPLANATION OF PLATES.

PLATE II.—Outline map of Block Island, showing location of Shell-heaps.

PLATE III.—Outline of Southern New England Coast.

Art. XIV.—*A Registering Solar Radiometer and Sunshine Recorder;* by Geo. S. Isham, A.M., M.D.

The object sought in making the machine about to be described was to get some simple form of registering apparatus which would give values in different places that could be compared, for that part of the total insolation of any place which goes to make it a source of convection currents, or what might be called the convectional potential of the place. To get absolute values for this seems an almost impossible thing to do, but if by any means reliable relative values can be obtained they will for many purposes be quite as valuable in studying the many problems of local winds, thunder storms, etc.

The black bulb is intended to represent any clod of earth or average matter exposed to the direct rays of the sun, and to all the winds that blow; the ordinary vacuum case is left off, as introducing far greater errors than it corrects. The shelter fulfills the above conditions as nearly as I can make it; a typical exposure would be an entirely unprotected one close to the ground. The position should be one that represents, as nearly as possible, the average of the locality.

The name solar radiometer is unsatisfactory, as it conveys the idea of a good deal more, and also something less, than is intended. Perhaps convectometer would be better. Its uses as a sunshine recorder, and as a means of measuring the heat given to vegetation are self-evident. For the latter use it would be better to color the tube green or treat it as De Blanchis has done in his investigations.

The machine has been given its present form as presenting a curve which requires the simplest corrections, there being no correction for pressure, specific gravity, or temperature. It is also simple enough to be understood and successfully run by persons not specially trained.

The instrument, in part like the registering barograph of Sprung, is made as follows: a long, straight scale beam C is balanced in the middle on a knife edge, resting on the support A. Each end of the beam supports on its upper side a perpendicular glass tube hung by a collar D fitted with knife-edge bearings, the collar being fastened a little above the middle point of the tube. These tubes dip into cups S, S1, connected together by a tube and capable of being raised or lowered by the screws T, T1. One of these tubes is covered with lamp-black above the collar.

Suspended from the beam by a rigid rod, with a screw thread on it, is the weight Q, by moving which balance may be

had in adjusting, and position of c. g. of the balance changed by changing its weight. On the beam next the blackened tube is a track on which runs the carriage E. This carriage is attached by the wire method, or by two universal motions to the arm F, which, in turn, is fastened to the nut G. The arm motion is limited to a right line parallel to the track by a rod which runs through a hole in the arm.

The nut G, which also carries the pen, is moved backwards and forwards by the screw H, geared to the perpendicular shaft I, which is broken by the universal motion J. The lower end of the shaft passes through a square block of soft iron, which block is limited by guides to a to-and-fro motion between the magnets K, K1; it then terminates in a gear wheel which engages either one of the wheels L, L1, according to which magnet is excited. A clock-work motor M, run by a weight and governed by a fly-wheel, turns the shaft, on which are the two gear wheels L, L1, always in the same direction. This motor is started or stopped by the magnet N, the armature of which moves a check to the fly-wheel.

From the back of the beam, in the middle, is a long pointer, terminating in platinum contacts (shown at the end of the beam in the drawing to avoid confusion). One or the other of these contacts, on the slightest motion of the beam, touches the point R or R1. The contact R is connected with the magnet K, and the battery and the contact R1 with the magnet K1 and the battery. The other pole of the battery runs through the magnet N and to the plate B on which the knife edge of the beam rests; the plate and the arm F being insulated, only the scale beam is in circuit.

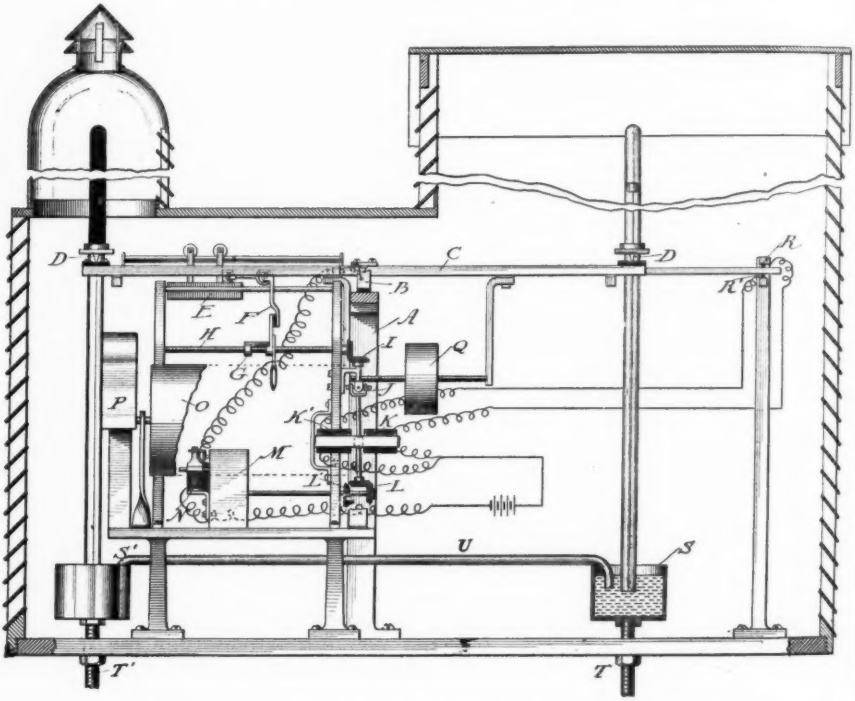
The tubes are filled with pure mercury and set in place in the same manner and with the same precautions as in filling a barometer tube, a liberal amount of mercury being left in the cups; the connecting tube is filled and put in place; then enough absolute alcohol is injected into each tube to insure, under all conditions of temperature and pressure, a saturated vapor of alcohol at the top.

An addition is built to the south side of an ordinary weather bureau shelter for thermometers, having a flat top and the same louver board sides; over a large hole in the top is put a glass cover; one-third of its circumference on the north is cut out and louver boards put in; on north side of the middle of the top of cover (not in middle as shown in cut) some form of lantern top is put. The ventilation must be as free as possible.

When the sun is not shining both tubes are of the same temperature and the tension of the alcohol vapor is the same in each; both tubes weigh the same, and the machine is in

equilibrium. This will be true whatever changes there may be in the temperature of the air, or the atmospheric pressure.

If the sun, or any source of heat, act upon the black tube the tension is increased, some mercury is forced out of the tube, the weight becomes less, contact is made at R1, the mag-



net K1 engages the wheel L1, the motor is started and the carriage is moved out upon the beam until the balance is restored, when contact is broken and the motor stopped.

When the source of heat is removed the tube cools, tension is decreased, amount of mercury is increased, equilibrium is disturbed, contact at R is made, and motion of carriage reversed and continued until equilibrium is again restored.

Secured to the nut G is a pen which moves with the nut parallel to the axis of a cylinder O, rotated once in twenty-four hours by the clock P.

The following dimensions for parts give good results: tubes $\frac{3}{4}$-inch inside diameter, 32·5 inches long; scale beam 30 inches.

The vapor chamber should be as small as possible, so the cups are arranged to be lowered or raised by screws in order to just accommodate, and no more, the largest probable change in temperature and pressure for the season, and to adjust for elevation above sea level. Because, as the tension of saturated vapor in any chamber is the tension of the coolest part; so the smaller the chamber the more sensitive it will be. The circumference of the cylinder O is 48 centimeters, which makes one millimeter equal three minutes of time. A difference of one millimeter in tension, by adjustment of the weight of carriage, causes a motion of two millimeters in the pen.

These dimensions seem to be large enough to nearly exclude mechanical errors and not too large for convenience. If more accurate values as regards time are required the motor should be arranged for two different speeds by having, for example, the first contact of the pointer made through a light spring, which starts the motor as above, but upon increase of weight it closes a second circuit which would raise a brake, or friction wheel, from the motor, thereby increasing the speed.

A motor that moves at a constant speed is either so slow that the pen falls behind a sudden change in temperature, or so fast that it causes oscillation on slight changes.

The use of a saturated vapor in this way I believe to be original. I have chosen ethyl alcohol as giving the best average results, though experience may prove that the use of ether in winter and alcohol in summer, or some such combination, may be better.

The difference in vapor pressure in millimeters of mercury of ethyl alcohol between 0° C. and 5° C. is about 5^{mm}, and lower down the difference is very much less, which would probably give inaccurate results.

To reduce the tracing on card there must be either a synchronous tracing, preferably on the same card, by a thermograph, or observations of a thermometer; for the curve represents the difference in temperature between a shaded and a black bulb thermometer.

The pen, when the sun is not shining, draws a straight line around the card which is the base line of measurement, but must have a different value for different temperatures. Suppose that at twelve o'clock, noon, on a certain day the curve measured $38{\cdot}4^{mm}$ from the base, and at the same time a sheltered thermometer or the thermograph trace showed a temperature of 25 C.; then, as the tension of alcohol vapor at 25 C. is $58{\cdot}86^{mm}$, adding half of the 38·4 (for the machine multiplies by two) the sum equals $78{\cdot}06^{mm}$, equals tension at 30 C., equals temperature of black bulb thermometer at that time. This may be done by simple inspection by making a transparent scale as follows:

Take a strip of glass or transparent celluloid, lay off from a base line which is marked 0° C. 10·14^{mm}, and make another mark and number it 5° C., for this distance is double the number of difference in millimeters of mercury of pressure of alcohol vapor, between 0° and 5° C., and so on all the way up and down the scale from the zero, taking the numbers from tables and interpolating by graphic method, values for degrees not given. Having made the scale, lay it on the card and put for every reading you wish to make the number representing the degrees temperature shown by the thermometer for that hour over the base line; then where the curve crosses the scale is the temperature of the black bulb at that time.

In order to compare the values of the reading for the same day at different places, I would suggest the following: the paper I have used is ruled in square millimeters and centimeters. It can be bought in any of the shops and serves the purpose; all that is necessary is to cut it in strips of the requisite width and mark a few of the hours on the transverse lines.

When reading the actual temperature by the scale for every half hour, hour or two hours, according to the accuracy desired, make a mark on the hour line at the intersection of the millimeter line corresponding to the number of degrees of difference between the shaded and black thermometer; e. g. if the difference is 12° make a dot at the intersection of the 12th millimeter line (measured from the base) with the hour line being measured. When they are all measured, join all these dots, and the area of the surface included between the base, and the irregular line so made, is the measure of the local insolation.

The thermograph should be arranged to trace its curve on the other side of the base line, one millimeter for each degree, or the curve may be plotted; then the area of the surface included between the two irregular curves so made is computed by inspection or by a planimeter; the number representing this area is purely arbitrary, but gives a good method of comparing any number of cards of the same or different places.

I think there are no corrections to be made for instrumental errors, other than mechanical ones, which is the advantage in using a saturated vapor, except in case of sudden change of temperature, when, though the machine acts almost instantaneously, it is slower than the actual change, but compares very favorably in rapidity with ordinary thermometers either mercurial or alcoholic.

The many ways of varying the machine will be evident upon a little reflection. The form as shown is simply the one that seems to me to be best; a better way of exposing it might alter its form greatly and simplify it, but I do not know of one which will protect it from wind and rain.

ART. XV.—*The Tertiary elevated Limestone Reefs of Fiji;* by ALEXANDER AGASSIZ.

DR. WILLIAM H. DALL has been kind enough to examine the fossil mollusks which I collected from the elevated limestone reefs in Fiji. He confirms the impression I had formed of their late Tertiary age.

Dr. Dall writes: "The fossils comprise Turbo, Cassis, Lithophaga, Macha, Tellina, Meretrix, Dosinia, Chama, Pholas and fragments of Pecten. None of the genera are extinct. The rock, however, looks decidedly too old for Pleistocene. I should say the fossils were younger than Eocene and might be either Miocene or Pliocene."

The boring which I started at Wailangilala Island in the atoll of the same name, was only carried to a depth of 85 feet. For 40 feet the tool passed through coral sand similar to that forming the shores of the island; from that depth down to 85 feet, the core consisted of a limestone similar in all respects to the limestone composing the elevated reefs we had observed at Ngele Levu, at Vanua Mbalavu, at Mango, at Yangasá, at Oneata, at Ongea, at Kambara, at Vatu Leile and at different points along the eastern, southern and western shores of Viti Levu. As at some points the elevated limestones attain a height of over 1000 feet (Vatu Vara Island, 1030 feet), nothing could be gained by continuing the boring at Wailangilala to obtain material which could be collected so readily in other localities; the boring was therefore abandoned.

The volcanic rocks underlying the elevated limestone reefs were observed at Vanua Mbalavu, at Mango, at Kambara and at several points along the southern and western coast of Viti Levu. To have continued to bore until we should strike the underlying rocks would have been equivalent to boring in localities where the base of the limestones had been but little elevated when it could be readily examined in the localities I have mentioned.

A renewed examination of the elevated reefs of the Paumotus, of the Friendly Islands, of the Gilbert, Ellice and other groups of atolls in the Pacific, will be needed to determine their age and correlation to the Fiji elevated limestones.

At any rate it is evident that the Tertiary coralliferous limestones of Fiji have not played any part in the formation of the atolls or islands encircled by recent coral reefs, beyond forming the substratum upon which the recent corals have grown and established themselves as a comparatively thin crust.

The underlying limestones have performed exactly the same part as the volcanic substratum in other islands of Fiji, such

as Totoya, Kimbombo, Wakaya, Makongai, Moala, Nairai, Ngau and others. In both cases the platform upon the top of which the corals grow has been prepared by extensive submarine erosion dating from the time when the limestones were elevated by the volcanic rocks which crop out everywhere in Fiji.

Professor David, of the University of Sydney, has been kind enough to assist me in obtaining the services of one of his students, Mr. E. C. Andrews, to collect fossils from the elevated reefs of Fiji. Mr. Andrews will spend a part of the summer in Fiji collecting material and exploring in detail some of the faces and slopes of the elevated reefs of the Archipelago, and I hope to obtain ample material to determine the age of these elevated limestones.

In the earlier discusions of the thickness of recent coral reefs by Darwin and Dana, no attention was paid to the possibility of the substratum of recent reefs consisting of Tertiary limestones. Elevated limestone containing corals of Tertiary age were considered as of recent origin and as pointing to a great thickness of modern reefs. It has been shown in Florida that the modern reef is not more than about 50 feet thick, and according to the borings from the artesian well at Key West is succeeded by Tertiary limestones, in which corals occur at intervals to a depth of 2000 feet.

It has been stated by Dana and others that the borings from the artesian wells at Honolulu to the rear of the shore line of the fringing reef of Oahu indicate a great thickness of modern reef corals. These statements are based upon the examination of samples of finely ground particles of limestone accompanied by an occasional fragment of coral, the age of which has not been determined. The statements are further supported by the evidence of Mr. J. A. McCandless, the engineer in charge of the boring, who asserted to Mr. Dana and myself that in boring all his wells the tool passed through a great thickness of corals, at various levels. During my recent visit at Honolulu I was fortunate to be on the spot when Mr. McCandless was boring a 10″ well about 2500 feet from the shore line and perhaps 7 feet above high water mark. Down to a depth of 80 feet nothing but recent reef coral rock was encountered, but from that point to a depth of over 300 feet the limestone passed through was of a very different character. It contained but few corals, being composed almost entirely of the shells of mollusks, mainly bivalves. The rock was white, chalky and resembled in every way the rocks of the Vicksburg age of Florida and of Yucatan; but their age has not yet been accurately determined. Enough, however, is clear to show that the limestones which form the substratum upon which rests the recent fring-

ing reef of Honolulu do not belong to the present period. Mr. McCandless assured me that limestones like those I had the opportunity of examining while the boring was going on, are identical with those to which he called Mr. Dana's and my attention in 1888, and that until I pointed out to him that the white limestone was almost wholly made up of Mollusca he had only paid attention to the occurrence of occasional corals and supposed the lower limestone to form the continuation of the recent modern reef. But as I have stated, this lower limestone differs from reef rock both lithologically and in its being made up of fossil mollusks.

It is very clear that when boring in a coral reef district in which it is difficult or impossible from other data to determine what geological changes may have taken place or the probable age of any limestone we may pass through in boring, it may be very easy to draw wrong conclusions both as to the age of the limestones and regarding the position of the line of demarcation between the modern coral reef and the underlying older limestone substratum.

If my conclusion that such atolls in the Fiji as Wailangilala, Ngele Levu and many others to which I shall refer in my final report, are formed upon platforms of marine erosion of elevated Tertiary limestones is correct, and if further in similar atolls in the Paumotus, the Gilbert, Ellice and other groups, the substratum underlying the modern coral reef is likewise composed of Tertiary limestones, it will become apparent that such boring as that carried on at Funafuti will not help us in any way to solve the problem of the formation of atolls by modern coral reefs. Such a boring, even should it reach the underlying volcanic substratum, will only give us the thickness of the Tertiary limestone beds forming the substratum upon which the modern coral reef has grown, a thickness which in the Ellice group can only be ascertained by boring, while in Fiji it can be ascertained approximately from the height of the islands composed of elevated Tertiary limestones.

Under what conditions these Tertiary coralliferous limestones of great thickness have been deposited is a distinct question from that of the formation of atolls through subsidence by the upward growth of corals during the present geological period. Neither the borings through a coral reef growing upon a substratum of Tertiary limestone, nor the examination of the outer edge of a coral reef formed upon a substratum of volcanic rocks, has given us (in Fiji) any evidence of the great thickness of a modern coral reef. On the contrary, all the evidence I have gathered in Fiji tends to prove that a coral reef forms only a comparatively thin crust upon the platform of submarine erosion (whatever be its geological structure) upon which it may have found a footing.

Art. XVI.—*The Iodometric Determination of Molybdenum;* by F. A. Gooch and John T. Norton, Jr.

[Contributions from the Kent Chemical Laboratory of Yale University, LXXII.]

A process for the iodometric determination of molybdic acid, which consists in treating a soluble molybdate in a Bunsen distillation-apparatus with potassium iodide and hydrochloric acid, has been advocated by Friedheim and Euler.* According to this process the molybdate, containing from 0·2 grm. to 0·3 grm. of molybdenum trioxide, is treated with from 0·5 grm. to 0·75 grm. of potassium iodide and enough hydrochloric acid, of sp. gr. 1·12, to fill two-thirds of the flask of the apparatus. The liquid is warmed until heavy vapors of iodine fill the flask and then boiled until iodine vapor is no longer visible and the color of the liquid residue is a clear green. The iodine liberated is collected in the distillate and titrated with sodium thiosulphate, every atom of iodine found indicating presumably the reduction of a molecule of molybdic acid to the condition of the pentoxide Mo_2O_5.

It was pointed out in a former article from this laboratory,† that greater precaution than was taken by Friedheim and Euler is necessary in order that the reduction may proceed according to theory, and that the iodine collected may serve as a reliable measure of the molybdic acid. It was found that the green color of the liquid comes gradually and that it may develop distinctly before the molybdic acid is fully reduced. It was found, also, that since even a trace of oxygen liberates iodine from the hot mixture of potassium iodide and hydrochloric acid of the strength employed, it is not sufficient to rely upon the volatilization of iodine to expel the air originally in the apparatus, but that it is essential to conduct the distillation in an atmosphere devoid of oxygen. The suggestion was made therefore that the operation should be carried on in a current of carbon dioxide and that the mixture, constituted definitely, should be boiled between stated limits of concentration which were determined by experiment. It was found that when amounts of a soluble molybdate containing less than 0·3 grm. of molybdenum trioxide are treated with potassium iodide, not exceeding the theoretical proportion by more than 0·5 grm., and 40$^{cm^3}$ of a mixture of the strongest hydrochloric acid and water in equal parts, the reduction proceeds with a fair degree of regularity and is practically complete when the volume has diminished to 25$^{cm^3}$. If the operation is pro-

* Ber. d. d. Chem. Gesell., xxviii, 2066.

† Gooch and Fairbanks, this Journal, IV, ii, 156.

perly conducted in an atmosphere of carbon dioxide, it was shown that the iodine in the distillate may be trusted to indicate the molybdic acid within reasonable limits of accuracy. It appeared, however, that too great an excess of potassium iodide tends to induce excessive reduction, and that the same tendency shows when the liquid is concentrated to too low a limit.

To this criticism Friedheim took exception* and contrasted, to their disadvantage, our results by the modified method with those of Friedheim and Euler by the original method. It became necessary, therefore, to point out† the fact that of the results published by Friedheim and Euler, upon which reliance was placed to prove the reliability of their method, five out of seven in one series and one out of five in another series had been calculated incorrectly from data given. Another series of six determinations was, however, apparently faultless in this respect. More recently‡ Euler has explained that the errors were not really arithmetical. Two of them may be presumed, inferentially, to be due to careless copying or proof-reading; and four, we are told by Euler, were introduced into the series by mistake, and actually represent (as Prof. Friedheim kindly informs him) the analysis of a sample of ammonium molybdate of undetermined constitution: that is to say, the figures now given by Euler represent the original percentages of molybdenum trioxide which had been changed by some unconscious process from

80·62	per cent	to	81.85	per cent.
80·71	"	"	81·69	"
80·63	"	"	81·67	"
80·78	"	"	81·78	"

Curiously enough, Euler's corrected figures, as given here, are still affected by trifling arithmetical errors of from one to four units in the second decimal place. The agreement of these results among themselves is no proof of the correctness of the process of analysis. The great variation between the average percentage of molybdenum trioxide in ammonium molybdate as found by Euler in a molybdate of known constitution and the percentage of the trioxide as found by Friedheim (if we understand Euler aright) may be due conceivably to either or both of two causes, viz: the change of material analyzed and the change of operator or conduct of the operation. We shall show in the following account of our work that the exact control of the conditions of treatment, along the lines laid down

* Ber. d. d. chem. Gesell., xxix, 2981.
† Gooch, this Journal IV, iii, 237.
‡ Zeit. f. Anorg. Chem.. xv, 454.

formerly, is actually essential to the reduction of molybdic acid according to the theory of the process.

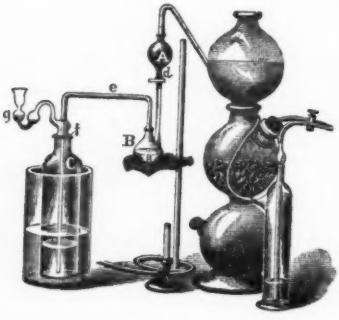
Our experiments were made with ammonium molybdate twice recrystallized from the presumably pure salt. The constitution of the preparation was determined by careful ignition *per se* and, for greater security, with sodium tungstate free from carbonate. It contained 81·83 per cent of molybdenum trioxide.

The potassium iodide which we used was prepared by acting with re-sublimed iodine upon iron wire, and precipitating by potassium carbonate—the proportions of iodine and iron having been adjusted to secure the formation of the hydrous magnetic oxide of iron. The filtrate from the iron hydroxide gave on evaporation and crystallization potassium iodide which was free from iodate.

The hydrochloric acid was taken of sp. gr. 1·12, because this is the strength used by Friedheim and Euler.

The sodium thiosulphate employed was taken in nearly decinormal solution, and was standardized by running it into an approximately decinormal solution of iodine which had been determined by comparison with decinormal arsenious acid made from carefully re-sublimed arsenious oxide. We chose this method of standardizing—the introduction of the thiosulphate into the iodine—rather than the reverse operation, in order that the conditions of the actual analysis might be followed in the standardization.

The distillation apparatus was constructed with sealed or ground joints of glass wherever contact with iodine was a possibility. It was made by sealing together a separating funnel A, a 100$^{cm^3}$ Voit flask B, a Drexel wash-bottle C, and a bulbed trap *g*, as shown in the figure. Upon the side of the distillation-flask B was pasted a graduated scale by means of which the volume of the liquid within the flask might be known at any time. Carbon dioxide, generated in a Kipp apparatus by the action of dilute hydrochloric acid (carrying in solution cuprous chloride to take up free oxygen) upon marble previously boiled in water, was passed through the apparatus before and during the operation, so that it was possible to interrupt the process of boiling at any point of concentration, to remove the receiver by easy manipulation, to



replace the receiver, and to continue the distillation without danger of admitting air to the distillation flask.

In experiments to be described– (1) to (5) of the table—the proportions of potassium iodide and molybdic acid, and the strength of the hydrochloric acid recommended by Friedheim and Euler were retained. The essential change of condition is the removal of atmospheric air from the distillation flask before the acid is admitted to contact with the other reagents. Potassium iodide (3 grm.) and water (200$^{cm^3}$) were put into the receiver C, and a little of this solution was allowed to flow into the trap *g*. Ammonium molybdate carefully weighed (0·3 grm.) and potassium iodide (0·5 gm. to 0·75 grm.) were introduced into the distillation-flask B, the apparatus was connected as shown in the figure and carbon dioxide was passed freely through the whole apparatus for some minutes. The stop-cock *d*, between the bulb of the funnel A and the flask B, was closed and hydrochloric acid (40$^{cm^3}$, sp. gr. 1·12) was poured into the funnel; the air above the liquid in the funnel was displaced by carbon dioxide through the space between the neck of the funnel and the loosely adjusted stopper carrying the inlet tube; the connection between the funnel and inlet tube was tightened, the stop-cock opened, and the acid, under the pressure of carbon dioxide, was permitted to flow into the flask. In this way the acid, iodide and molybdate were made to interact with little danger of the presence of oxygen. The flask was heated by the Bunsen burner and the iodine evolved, passing over quietly in the slow current of carbon dioxide, collected in the receiver. The liquid was boiled until fumes of iodine were no longer visible above the liquid in the flask and connecting tubes backed by a ground of white, and then a full minute more. At this stage, the green color of the liquid having developed fully, the apparatus was permitted to cool, the current of carbon dioxide was increased, the cap of the receiver was loosened at *f*, the contents of the trap were washed back into the receiver, the rest of the apparatus was lifted bodily from the receiver, the liquid adhering to the inlet-tube was washed off into the receiver and the end of the tube was dipped immediately into a solution of potassium iodide. The constant flow of carbon dioxide prevented reflux of air during the transfer, and as soon as the end of the tube had been submerged in the solution of potassium iodide (which was employed not only as a water-seal, but to catch any iodine still carried in the gas), it was possible to reduce the rapidity of the current.

After titrating the iodine in the distillate the receiver was again placed in the train and the process of distillation was resumed under the former conditions and continued until the

volume of the liquid, as indicated upon the scale, had diminished to 25$^{cm^3}$, when the distillation was interrupted. The apparatus was manipulated as before to prevent access of air, and the iodine evolved in the second treatment determined. A third period of distillation served to show the iodine liberated during the concentration of the liquid from 25$^{cm^3}$ to 10$^{cm^3}$.

A

	HCl Sp. gr. 1·12 taken.	KI in retort.	MoO_3 taken as ammonium molybdate.	MoO_3 corresponding to iodine found.		
				1st stage 40$^{cm^3}$ to 32$^{cm^3}$. Green color.	2d stage 32$^{cm^3}$ to 25$^{cm^3}$.	3d stage 25$^{cm^3}$ to 10$^{cm^3}$
	cm^3	grm.	grm.	grm.	grm.	grm.
(1)	40	0·5	0·2455	0·2399	0·0076	0·0004
(2)	40	0·5	0·2455	0·2402	0·0053	0·0013
(3)	40	0·5	0·2455	0·2414	0·0040	0·0004
(4)	40	0·75	0·2455	0·2404	0·0061	0·0004
(5)	40	0·75	0·2455	0·2431	0·0037	0·0004
(6)	40	1·	0·2455	0·2404	0·0085	0·0019
(7)	40	2·	0·2455	------	-----	-----

B

	MoO_3 corresponding to iodine found during period of Friedheim and Euler. (1st stage.) grm.	Error. grm.	MoO_3 corresponding to iodine found in concentrating from 40$^{cm^3}$ to 25$^{cm^3}$. grm.	Error. grm.	MoO_3 corresponding to iodine found in concentrating from 40$^{cm^3}$ to 10$^{cm^3}$. grm.	Error. grm.
(1)	0·2399	0·0056—	0·2475	0·0020+	0·2479	0·0024+
(2)	0·2402	0·0053—	0·2455	0·0000	0·2468	0·0013+
(3)	0·2414	0·0041—	0·2454	0·0001—	0·2458	0·0003+
(4)	0·2404	0·0051—	0·2465	0·0010+	0·2469	0·0014+
(5)	0·2431	0·0024—	0·2468	0·0013+	0·2472	0·0017+
(6)	0·2404	0·0051—	0·2489	0·0034+	0·2508	0·0053+
(7)	------	------	------	------	0·2495 0·2529*	0·0040+ 0·0074+

* On repeating distillation with a fresh charge of acid.

During the first period of distillation the liquid assumed the clear green color, which changed but slightly until the beginning of the third period, when the tint verged upon olive, and

at the end of the operation the color of the liquid was an olive brown which grew browner on cooling. The addition of considerable hydrochloric acid to the residual liquid restored the clear green color, while water changed the olive brown to reddish yellow, the tint varying with the dilution. The results of these experiments are recorded in (1) to (5) of the accompanying table. In division A are given the weights of molybdenum trioxide corresponding to the amounts of iodine found in the three stages of distillation; in division B, the molybdenum trioxide corresponding to the iodine evolved from the beginning of the process to the end of each stage.

The mean error of the indications taken during the period of distillation advocated by Friedheim and Euler is 0·0045 grm.—;* that of the period of concentration from 40$^{cm^3}$ to 25$^{cm^3}$ is 0·0008 grm.+; and that of the full period of distillation is 0·0014+. It is plain beyond a peradventure that in the process as conducted by Friedheim and Euler, excepting the protection against atmospheric action, the theoretical reduction of the molybdic acid does not take place. The best results are obtained when the distillation is prolonged until the original volume of 40$^{cm^3}$ has been diminished to 25$^{cm^3}$. Concentration beyond the limit of 25$^{cm^3}$ tends to develop a tendency toward over-reduction, especially when the amount of potassium iodide is increased beyond about 0·5 grm. in excess of that theoretically required. This is shown in experiments (6) and (7), conducted otherwise similarly to those described above, in which the amount of potassium iodide was increased to 1 grm. and 2 grm. The error after distilling from 40$^{cm^3}$ to 10$^{cm^3}$, the lowest limit of the preceding experiments, was 0·0053 grm.+ and 0·0040 grm.+, and the latter error was increased to 0·0074 grm.+ on repeating the distillation with a fresh portion (30$^{cm^3}$) of the acid. It is interesting to note incidentally that in the experiment in which the largest amount of iodide (2 grm.) was used the solution did not take the green color at any stage of the distillation, probably because the large excess of iodide held the free iodine and so masked the color until the degree of concentration was reached at which the olive brown color displaces the green.

The possibility of the interaction of atmospheric oxygen and gaseous hydriodic in the analytical process, even to the extent of producing errors of from one to three per cent reckoned as molybdenum trioxide, was recognized by Friedheim and Euler; and it was to obviate this difficulty that the recommendation was made by them to warm very gradually the distillation flask filled two-thirds with the mixture of iodide, molybdate

* Even this figure does not disclose the full error, which is partly counterbalanced, as will appear later, by the effect of oxygen dissolved in the acid used in the process.

and acid, and to raise the liquid to actual boiling only when the space above the liquid in the retort and in the connecting tube is filled as completely as possible with iodine vapor, while the liquid in the receiver begins to rise in the tube.

The action of atmospheric oxygen upon the solution of hydriodic acid must, however, be also taken into acconnt. It is a familiar fact that when a considerable excess of strong hydrochloric acid is allowed to act in contact with air upon potassium iodide (free from iodate) dissolved in a little water, the mixture is colored by free iodine. The amount of iodine liberated by atmospheric action is insignificant when the acid is very dilute, but is considerable when the acid is strong, and increases with time and rise in temperature, as shown in the experiments recorded in the accompanying table.

KI taken. grm.	Volume. cm^3.	Percentage of HCl in aqueous acid.	Time in minutes.	Temperature, Centigrade.	MoO_3 equivalent to iodine found. grm.	Remarks.
1	66	2	1	23°	none	
1	66	2	10	23°	0·0001	
1	66	24*	10	23°	0·0017	Diluted to 500^{cm^3} before titrating with $Na_2S_2O_3$
1	66	24*	4	From 23° to the boiling point	0·0067	
1	66	24*	10		0·0121	

Even the precaution to conduct the operation in an atmosphere of carbon dioxide does not eliminate all chance of error of this sort unless the liquid of the mixture—the hydrochloric acid—is free from air. The experiments of the following statement, which were conducted in the apparatus and manner previously described, show this point clearly. Thus, 40^{cm^3} of unboiled acid, sp. gr. 1·12, introduced enough air into the apparatus to cause an error of 0·0013 grm. reckoned in terms of molybdenum trioxide, while the iodine set free by the action of the residual acid of this experiment upon another gram of potassium iodide introduced without admission of air corresponded to only 0·0002 grm. in terms of molybdenum trioxide. The use of acid of sp. gr. 1·1, freshly boiled in the air, obviously reduces the error due to the unboiled acid, but even in this case the effect of included oxygen was not wholly obviated.

*This corresponds nearly to sp. gr. 1·12.

KI taken. grm.	Vol. cm^3.	Percentage of HCl in aqueous acid.	Concentration by boiling cm^3.	MoO_3 equivalent to iodine found. grm.	Remarks.
1	40	24	40–30	0·0013	Iodine determined in distillate.
			30–20	0·0002	1 grm. of KI added to retort at the beginning of the 2d stage.
1	40	20	40–25	0·0005	The acid taken, sp. gr. 1·1, was freshly boiled and introduced at once upon KI in retort in CO_2.

It is obvious that the procedure recommended by Friedheim and Euler can by no possibility eliminate the effect of atmospheric action upon the mixture of acid and iodide. The extent of such action must depend upon such conditions as the size of the apparatus, the time of exposure, the body of air above and dissolved in the liquid, and the rate of displacement of the air. How great the error due to atmospheric action actually was in the process as conducted by Friedheim and Euler we, of course, have no means of knowing. It is to be hoped, however, that it was sufficiently great to counterbalance that other inevitable error (of about five milligrams) which exists by reason of the incompleteness with which molybdic acid is reduced under the conditions which these investigators prescribe; for, the value of Euler's work upon the vanadiomolybdates rests upon the chance that these two very considerable and indisputable tendencies to error may have neutralized one another.

It has been shown clearly that our former criticism of the procedure of Friedheim and Euler is justified in every particular. We have no change to make in the recommendation made therein as to necessary modifications.

If the conditions seem difficult, there is an alternative in the method proposed in the former article*, according to which the molybdate is reduced by the acid and iodide in an Erlenmeyer beaker (trapped loosely by means of a short bulbed tube hung in the neck) and the molybdenum pentoxide, freed from iodine by boiling, is reoxidized by standard iodine in alkaline solution.

* This Jour. IV, ii. 156.

ART. XVII.—*Sölvsbergite and Tinguaite from Essex County, Mass.;* by HENRY S. WASHINGTON.

A VISIT to the Christiania Region made last summer, in company with other American and English geologists, under the guidance of Prof. W. C. Brögger, greatly added to an interest in the closely parallel region of igneous rocks of Essex Co., Massachusetts, which had been already awakened through several visits. A series of microscopical and chemical examinations was undertaken, with the aim of comparing the two regions. In the course of this several rocks were shown to be types of such peculiar interest that it was decided to publish their descriptions in advance of a more general paper on the subject.

Glaucophane-Sölvsbergite.—The only mention of rocks belonging here, which I can find, consists of brief notes by Shaler* based on observations by R. S. Tarr, who describes dikes 3, 182 and 184 as quartz and feldspar porphyries containing glaucophane in the groundmass. Rocks from all these have been collected, but the specimens most thoroughly examined came from dike 184,—or rather from No. 184a of his list of dikes (p. 593).

The dike occurs at Andrew's Point, the northeastern extremity of Cape Ann, cutting the granite and running into the sea. It averages about 4 feet in thickness, with a strike of N. 45° W. (Shaler) and vertical dip. The structure is schistose parallel to the walls (well brought out by weathering), and it is split by joint-planes almost at right angles to its length. These joint-planes coincide with a secondary system of planes cracking the granite on either side, in most cases passing uninterruptedly from one into the other, and it is evident that both were acted on by the forces producing these simultaneously. There is no evidence of contact action on the granite, but the dike rock becomes notably coarser-grained toward the center, though still remaining fine-grained. The dike rock also carries two or three small inclusions of the wall material, and sends off a few slender apophyses. There can be absolutely no doubt that it is a true dike of igneous origin.

The rock is rather dark, slightly bluish gray, fine-grained and compact, and splits quite readily parallel to the walls. No phenocrysts are visible. The specific gravity is 2·703 at 22° C.

Under the microscope the rock shows a holocrystalline, microgranitic structure. True flow structure is not marked, but the schistose character is rendered evident by long streaks

* Shaler, Geology of Cape Ann, 9th Ann. Rep. U. S. G. S., 609, 1889.

of blue hornblende crystals. The constituents are *alkali-feldspar*, *quartz* and *blue hornblende*, with accessory *titanite*, *cordierite*, *apatite*, and an undetermined mineral.

The *feldspar* and *quartz* form a typically microgranitic intergrowth, the former being far more abundant than the latter. Both are xenomorphic, only occasional roughly lath-like feldspars being visible. The feldspar shows often between crossed nicols the moiré appearance common in the anorthoclases. Carlsbad twins are rather common, and some multiple twinning lamellæ are to be observed. The feldspars are perfectly fresh and clear, and contain, like the quartz grains, scarcely any inclusions.

The *hornblende*, which is the most characteristic component, is scattered fairly uniformly through the rock, though there are areas relatively rich or poor in it. The arrangement in streaks has been already noted.

The hornblende grains do not show crystal planes and are irregular in shape, not acicular, as is generally the case with these species. Prismatic cleavage at about 124° is prominent. The color in ordinary light varies with the direction of the section; those cut perpendicular to $\dot{c}$ are greenish yellow, while those parallel are dark or lighter blue-gray.

The extinction-angle is small, measurements with a Bertrand's ocular varying from 4°–7°; probably the latter figure comes near the truth. Whether the extinction was positive or negative could not be determined owing to the absence of crystallographic planes. Pleochroism is very intense; parallel to $\dot{c}$ dark (almost opaque) blue gray, parallel to $\dot{b}$ the same or a little lighter, and parallel to $\dot{a}$ pale greenish yellow. The determination of the axes of elasticity was rendered difficult by the intense coloration of the mineral, but a large number of observations both with the mica plate and quartz wedge seemed to show that the axis of least elasticity c lay nearest the vertical axis. The absorption formula then would be $c \geqslant b > a$.

This determination, if correct, would indicate that the hornblende is glaucophane, and this view is sustained, as will be seen later, by the results of a chemical analysis of the rock, from which it appears that the hornblende is a mixture of ferrous glaucophane and riebeckite molecules in the ratio of 3 to 2.

Titanite occurs in colorless grains of fair size, with the usual characters, and calls for no special comment.

There also occur some very small, highly irregular grains of a clear, doubly refracting mineral, either colorless or very pale violet, in the latter case pleochroic to a scarcely noticeable extent. The refractive index is not high and the double

refraction small, and the grains might be mistaken for quartz were it not for the color. Although no pleochroic halos were seen, the mineral is referred to *cordierite*. It may possibly be a foreign inclusion, brought up from below, but this point cannot be settled.

There are also seen a number of small, slender, light yellowish needles, which extinguish parallel to their length, and in some cases are very faintly pleochroic, with the absorption $\epsilon > \omega$. These are apparently *apatite*, though small irregular flakes of a similarly appearing substance do not show the usual form of this mineral, and they may possibly be *rosenbuschite*, which is said to occur in North American nepheline-syenites.*

The results of a chemical analysis by the writer are given in No. I.

	I.	II.	III.	IV.	V.
SiO_2	64·28	62·70	64·92	64·33	64·21
TiO_2	0.50	0·92	....	trace	....
Al_2O_3	15·97	16·40	16·30	17·52	16·98
Fe_2O_3	2·91	3·34	3·62	3·06	6·69
FeO	3·18	2·35	0·84	0·94	....
MnO	trace	trace	0·40	0·35	....
MgO	0·03	0·79	0·22	0·34	0·18
CaO	0·85	0·95	1·20	0·56	0·49
BaO	none	....	....	....	....
Na_2O	7·28	7·13	6·62	7·30	5·13
K_2O	5·07	5·25	4·98	4·28	4·41
H_2O, 110°	....	....	....	0·04	....
H_2O, ignit.	0·20	0·70	0·50	0·95	1·00
P_2O_5	0·08	....	....	trace	....
	100·33	100 53	99·60	99·67	99·09

I. Glaucophane-Sölvsbergite. Dike 184. Andrew's Point, Cape Ann, Mass. H. S. Washington anal.

II. Katoforite-Sölvsbergite. Lougenthal, Norway. Brögger. Grorudite-Tinguaite Serie, 80. L. Schmelck anal.

III. Aegirite-Sölvsbergite, Sölvsberget, Gran, Norway. Brögger, op. cit., 78. L. Schmelck anal.

IV. Aegirite-Sölvsbergite (Acmite-Trachyte), Crazy Mountains, Montana. Wolff and Tarr, Bull. Mus. Comp. Zool., xvi, 232, 1893. W. H. Melville anal.

V. "Aegirite-Trachyte." Kühlsbrunnen, Siebengebirge. Cited in J. Roth, Gesteins analyse, 1861, 21. Bischof anal.

The chief characteristics are medium acidity, high alkalies, especially soda, rather high FeO, and low MgO and CaO. These characters are well expressed in the mineral composition, which, since the rock is holocrystalline and of simple composition, is readily calculated to be as follows:

* Rosenbusch, Mikr. Phys., i, 510, 1892.

	Ia.	IIa.	IIIa.
Glaucophane	13·8	---	----
Riebeckite	10·6	----	----
Hornblendes	----	14·7	....
Pyroxene (Aegirite)	----	2·5	15·5
Albite	39·0	51·	50·5
Orthoclase	29·8	30·	29·5
Quartz	4·3	0·7	4·5
Titanite	1·9	----	----
Cordierite	0·3	----	----
Apatite	0·3	----	----
Accessories	----	1·0	----

In this calculation the small amount of CaO is just sufficient to satisfy TiO_2 and P_2O_5 to form titanite and apatite, and the trace of MgO is used up in cordierite. It is evident therefore that the blue hornblende is not the lime-bearing arfvedsonite, and that the glaucophane molecule present is not the usual magnesian one. We therefore have to assume a glaucophane molecule in which RO is entirely FeO, and on this basis the hornblende as a whole is represented by the formula Gl_3Rb_2. It may be noted, *en passant*, that poverty in MgO is characteristic of all the rocks of the region so far analyzed; and in this connection the occurrence of the rare, purely ferrous olivine, fayalite, at Rockport* may be recalled.

In view of the close resemblance in chemical and mineralogical composition, as well as genetic relationships, with the sölvsbergite of Norway, the present rock must be classed with them, and may be distinguished specifically as a *Glaucophane-Sölvsbergite*. This group was first described as such by Brögger in 1894 and embraces medium to fine-grained dike rocks composed largely of alkali feldspar, with soda pyroxenes or soda hornblendes, either without quartz or very poor in it, and consequently of medium acidity. Analyses of Brögger's Sölvsbergites are given in Nos. II and III and their comparison with I is instructive. II is of a hornblende (katoforite) sölvsbergite and it is seen to be almost identical with I, the slightly lower SiO_2, and higher MgO being the only noteworthy differences. III is of an aegirite-sölvsbergite and this also is closely similar, the chief difference here being the considerably lower FeO as compared with our rock. This difference seems to have determined the formation of ægirite rather than a soda hornblende, since we find the same features in the analysis of the so-called "acmite trachyte" of the Crazy Mts. given in No. IV, a rock which is referred to the Sölvsbergites by Rosenbusch.† The mineral composition of the Norwegian

* Penfield and Forbes, this Journal, IV, i, 129, 1896.
† Rosenbusch. Mikr. Phys, ii, 476, 1896.

sölvsbergites, as calculated by Brögger, is given in II*a* and III*a*, and they are seen to be poorer in dark minerals and richer in the albite molecule. The mineral composition of the rock represented in IV could not be satisfactorily calculated. An analysis by Bischof of the "aegirite-trachyte" of Kühlsbrunnen in the Siebengebirge is given in V, and is seen to be closely similar to the others, though the lack of separate determinations of Fe_2O_3 and FeO and its date (1852) render it less valuable than one might desire. It is chiefly of interest as an instance of rocks of practically the same chemical and mineralogical composition occurring in connection with magmas of quite diverse characters.

In connection with the above rock it may be mentioned that closely similar rocks occur in Shaler's dike 182 (south of 184), near Pigeon Cove, and from a dike near Bass Rocks, east of Gloucester. The rock of dike 3, at Magnolia, is of similar character, but is remarkable for the abundance of well crystallized phenocrysts of feldspar and quartz. Specimens were collected from these localities this summer, but too late for description in this paper.

The rocks described above are of interest in view of the increase in localities of blue hornblendes identified in recent years, and call attention to the fact that such hornblendes are by no means uncommon in the igneous rocks of Eastern Massachusetts, just as they are frequent in similar rocks of the Norway region.*

Mr. T. G. White has recently described† the well known granite of Quincy, Mass., and has found that it contains a blue hornblende which he refers to glaucophane. This occurrence seemed of such importance that an analysis was deemed desirable, and through his kindness, for which I express my hearty thanks, I was put in possession of a specimen collected by himself. The results of an analysis made by me are given below in No. I. It will be seen that, as compared with the analysis of the sölvsbergite the differences are chiefly those depending on the higher acidity, with the exception of the relative amounts of Fe_2O_3 and FeO, which determined the character of the hornblende.

The character of the rock admits of a very satisfactory calculation of the mineral composition, with the result given in I*a* below. From this it appears that while the composition in general is analogous to that of the sölvsbergite, yet that there are one or two differences of note. While the absolute and relative amounts of albite and orthoclase do not greatly differ, quartz, instead of being quite subordinate in amount, takes

* Cf. Brögger, op. cit., 186, and Zeit. Kryst., xvi, 411, 1890.
† T. G. White, Proc. Bost. Soc. Nat. Hist., xxviii, 128, 1897.

second place. The hornblende is considerably lower, and instead of glaucophane (ferrous also) predominating over the riebeckite molecule, the latter surpasses the former, its composition being expressed by the formula Rb_6Gl_2. It is hence essentially a riebeckite rather than a glaucophane.

	I.	II.	III.	IV.	V.
SiO_2	73·93	71·65	73·35	74·35	70·15
TiO_2	0·18	trace	----	----	0·65
Al_2O_3	12·29	13·04	14·38	8·73	10·60
Fe_2O_3	2·91	2·79	1·96	5·84	5·77
FeO	1·55	1·80	0·34	1·00	1·74
MnO	trace	trace	----	0·22	0·52
MgO	0·04	trace	0·09	0·07	0·35
CaO	0·31	trace	0·26	0·45	0·72
BaO	none	----	----	----	----
Na_2O	4·66	6·30	4·33	4·51	5·30
K_2O	4·63	3·98	5·66	3·96	4·09
H_2O	0·41	1·10	----	0·25	trace
	100·91	100·66	100·37	99·38	99·89

I. Granite, Hardwick Quarry, Quincy, Mass. H. S. Washington, anal. Sp. gr. 2·642 at 22° C.

II. Soda Granite, Houguatten, Norway, Brögger, Gror. Ting. Ser. 127. L. Schmelck, anal.

III. Paisanite, Paisano Pass, Texas, Osann, Tsch. Min. Pet. Mitth., xv, 439, 1895. Osann, anal.

IV. Grorudite, Varingskollen, Norway, Brögger, op. cit. 48. Särnström, anal.

V. Grorudite, Grussletten, Grorud, Norway, Brögger, op. cit. 48. V. Schmelck, anal.

	I*a*.	II*a*.	III*a*.	IV*a*.	V*a*.
Riebeckite	12·3	10·	6·	----	----
Glaucophane	2·0	4·	----	----	----
Ægirite	----	----	----	21·6	22·5
Albite	27·7	40·	32·	19·1	29·5
Orthoclase	27·2	23·	35·	21·8	24·5
Quartz	30·2	23·	27·	37·5	23·5
Accessories	0·6	----	----	----	0·5

In column II is given an analysis of a typical soda granite of Norway, which, according to Brögger is composed of alkali feldspar, quartz and blue hornblendes, with small amounts of magnetite, zircon, apatite, etc. It is closely parallel to our granite, the only differences of note being lower SiO_2 and correspondingly higher Na_2O. The results of a roughly approximate calculation based on Brögger's analysis and description are given in IIa, the hornblende being assumed from his de-

scription and the lack of CaO to be a mixture of riebeckite and glaucophane. Here also it much resembles the Quincy granite, though albite is higher and quartz and orthoclase lower. The hornblende is much the same in character and is of about the composition Rb_5Gl_2, the glaucophane here also being purely ferrous.

A comparison with the paisanite of Osann (III and III*a*) is also of interest. On the whole they are closely similar, though in paisanite the iron oxides, especially FeO, are lower and K_2O higher. Corresponding to this the mineral composition (calculated by Osann) shows rather more orthoclase, and the hornblende is almost a pure riebeckite containing only traces of glaucophane.

All the above calculations are of interest in pointing to the existence of a purely iron-alumina glaucophane.

Two analyses of grorudites given by Brögger are cited in IV and V, their mineral composition as calculated by Brögger being given in IV*a* and V*a*. These show, relatively toward the riebeckite granites and paisanite, much the same state of affairs which we remarked on in the sölvsbergites; in the aegirite-bearing grorudites Fe_2O_3 is much higher relatively to FeO. In the grorudites however Al_2O_3 is very considerably lower than in the others—facts which have been commented on by Brögger (op. cit. 128) and by Osann (op. cit. 441). The grorudites are much higher also in dark minerals.

It is to be seen from the above that from the classificatory standpoint, grorudite and sölvsbergite do not stand on precisely the same plane, the latter being broader than the former. The sölvsbergites include both soda-pyroxene and soda-hornblende rocks, the latter being distinguished from the former in nomenclature by the use of the name of the hornblende. The grorudites are essentially aegirite rocks, (katoforite and other soda-hornblendes occurring in subordinate amounts), while their hornblende-bearing equivalents are known as paisanite, the effusive form being the comendite of Bertolio.* This is, of course, a small matter, but significant of the present state of confusion in petrographical nomenclature and classification, and of the pressing need of some systematization.

Tinguaite.

Analcite-Tinguaite.—The rock which is here discussed forms a small dike cutting the granite of Pickard's Point, south of Singing Beach, at Manchester. It also cuts a wide dike of diabase, or rather labradorite-porphyrite, with large pheno-

* I follow Brögger (op. cit. 63–65) rather than Rosenbusch (op. cit. 614), who correlates the comendites with the paisanites and the grorudites with the pantellerites.

crysts of labradorite, some of which measure over 10^{cm} in length. The tinguaite was discovered by Mr. J. H. Sears of Salem, Mass., who described it in 1893.* It is also briefly noticed by Rosenbusch,† who speaks of it as "an eminently fresh and typical tinguaite, with rather greasy luster, and lighter in color than usual. The small, rare phenocrysts are microcline and microcline-microperthite. In the groundmass there appears to be present some analcite pseudomorphous after leucite."

Although the rock has been described by Sears, yet a description of the specimens in my possession will not be out of place, in view of certain features to be discussed later.

The rock is very compact, tough and aphanitic, with a silky sheen, and the slightly greasy luster common to the tinguaites. Its color is olive-green, varying somewhat in different specimens, from greenish gray to greenish black. A few white feldspar phenocrysts are visible. The specific gravity was determined by the balance to be 2·474 at 22° C.

In thin section the freshest specimens (obtained by Mr. Sears from blasting, and toward the center of the dike), show a structure characteristic of such rocks—needles and larger grains of aegirine, with many needles and a few phenocrysts of feldspar, lie in a clear, colorless groundmass, which in general is isotropic, but which here and there shows faint double refraction. The rock is *perfectly fresh*, no trace of decomposition being observed in any of the constituents. There are no evidences of flow structure.

The *aegirite* occurs as slender needles and as larger, generally elongated, crystal fragments. It is perfectly fresh and carries no inclusions, beyond an occasional minute speck. The extinction angle, measured on many sections which (as shown by the pleochroism) were approximately parallel to *b* (010), was found to be about 7°. The axis of elasticity lying nearest to *c* was determined by means of the mica plate to be a. Pleochroism is rather feeble; a slightly bluish green, b yellowish green, c slightly brownish green to yellow. The difference of absorption was slight; c about equal to a, and this slightly greater than b. Some of the larger crystals show cores of a brownish yellow, non-pleochroic pyroxene, but this is present in very small amount.

Only a few of the *feldspar* phenocrysts were visible in the sections. I could find no microcline twinning, and, as far as my observations go, judging chiefly from the moiré appearance,‡ they seem to be anorthoclase rather than microcline.

* J. H. Sears, Bull. Essex Institute, xxv. 4, 1893.
† Rosenbusch, Mikr. Phys., ii, 483, 1896.
‡ Cf. Pirsson, this Journal, ii, 196, 1896.

One case of Carlsbad twinning was seen, and here and there a microperthitic structure was very evident. The small feldspars of the groundmass are slender needles—probably of anorthoclase—elongated (as shown by use of the quartz wedge), parallel to *à*. The extinction is either parallel or at very small angles.

A few very small, colorless crystals of high refractive index and double refraction, are supposed to be *zircon*. None of the sodalite spoken of by Sears could be seen, though the analysis shows that some of it is present. Magnetite is entirely absent.

The clear, colorless, micro-groundmass in which the above minerals lie is holocrystalline, and composed of *nepheline* and *analcite*. These form irregular areas of varying sizes, passing rather indefinitely from one into the other. Those of nepheline are distinguished by their faint double refraction, lack of cleavage, and by the fact that the index of refraction is, as shown by Becke's method, rather higher than that of the anorthoclase needles. One or two fair-sized crystals of nepheline were observed. The patches of analcite are readily distinguished by their cubic cleavage, exhibited by well-defined straight cracks crossing at right angles, by their generally isotropic character, and by the fact that their refractive index is notably lower than that of the feldspars. In places they show a very faint double refraction, analogous to that of leucite, but not as well marked. While the aegirite and feldspar needles are scattered through both, yet the analcite areas are rather poorer in them than those of nepheline. The areas of both, when treated with HCl, gelatinize easily and stain with fuchsine. It must be mentioned that on a first cursory examination the analcite was passed over as nepheline, and it was not until the H_2O determination of the analysis showed a percentage in striking contrast with the freshness of the rock that the presence of analcite was definitely determined.

The freshest specimens from near the borders of the dike show characters analogous to the preceding, though they are much finer-grained, and apt to be somewhat decomposed.

A chemical analysis was made on a specimen from near the center of the dike, obtained by blasting, this being far fresher than those collected by myself. For it, as well as for other material from this region, I am deeply indebted to the liberality of Mr. J. H. Sears. The results are given in No. I.

The analysis is seen to be that of an almost normal tinguaite; silica, iron oxides, magnesia and lime not varying materially from the figures of other analyses. Soda is, however, higher and potash very much lower than in any other, this rock being the poorest in K_2O of any tinguaite yet fully described. H_2O is high for a rock of the freshness of this one.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2	56·75	56·58	55·65	53·21	54·07	54.46	58·70	58·64
TiO_2	0·30	....	....	0·35	0·15	trace	trace	0·20
ZrO_2	....	....	....	....	....	....	....	0·09
Al_2O_3	20·69	19·89	20·06	22.02	21·67	19·96	19·26	19·62
Fe_2O_3	3·52	3·18	3·45	4·18	3·55	2·34	3·37	2·17
FeO	0·59	0·56	1·25		....	3·33	0·58	0·42
MnO	trace	0·47	....	0·42	....	trace	0·10	0·20
MgO	0·11	0·13	0·78	0·91	0.36	0·61	0·76	0·37
CaO	0·37	1·10	1·45	1·33	0·36	2·12	1·41	1·24
BaO	none	....	....	....	....	....	....	trace
SrO	....	....	....	....	....	....	....	trace
Na_2O	11·45	10·72	8·99	10·37	8·91	8·68	8·55	8·39
K_2O	2·90	5·43	6·07	6·41	4·76	2·76	4·53	5·26
H_2O 110°—	0·04	....	....	....	....	....	0·07	0·34
H_2O 110°+	3·18	1·77	1·51	0·81	5·44	5·20	2·57	2·40
P_2O_5	....	....	....	....	....	....	0·10	0·03
SO_3	trace	....	....	....	....	....	....	trace
Cl	0·28	....	....	....	....	....	....	0.14
CO_2	....	....	....	....	....	....	....	0·23
	99·92	99·83	99·21	100·01	99·27	99·46	100·0	99·74

I. Tinguaite, Pickard's Point, Manchester, Mass. H. S. Washington, anal.

II. Tinguaite (dike border), Hedrum, Norway, Brögger, Gror. Ting. Ser. 113. G. Pajkull, anal.

III. Tinguaite (dike center), Hedrum, Norway, Brögger, Gror. Ting. Ser. 191. V. Schmelck, anal.

IV. Tinguaite Porphyry, Foia, Serra de Monchique, Portugal, Kraatz-Koschlau and Hackman, Tsch. Min. Pet. Mitth., xvi, 257, 1896. Mean of three poor analyses by students of Jannasch.

V. "Aegirite Tinguaite," Hot Springs, Ark., J. F. Williams, Ark. Geol. Surv., 1890, ii, 370. W. A. Noyes, anal.

VI. Tinguaite, Njurjawpachk. Umptek. Kola, Ramsay and Hackmann, Neph. Syen. Geb. Kola, Fennia 11. No. 2, 158, 1894. K. Kjellin, anal.

VII. "Acmite Trachyte," Crazy Mts., Mont., Wolff and Tarr, Bull. Mus. Comp. Zool., xvi, 232, 1893. W. H. Melville, anal.

VIII. Phonolite, Cripple Creek, Colorado, 16 Ann. Rep. U. S. G. S., ii, 39, 1895. W. F. Hillebrand, anal.

The rock which approaches closest to it is the tinguaite from the dike border at Hedrum, Norway (No. 2), the two being almost identical, except in K_2O and H_2O. Its relations to other tinguaites may be seen in the table, from which those very rich in potash are excluded.

The calculation of the mineralogical composition is somewhat uncertain, owing to the presence of three soda-alumina silicates, nepheline, albite and analcite, and ignorance of what amount of the H_2O present really belongs to the last. An attempt has been made in No. I*a*, which, though only very roughly approximate, corresponds fairly well with the rock as seen in thin sections. This calculation was subsequently checked by determination of the portion of the rock soluble in dilute HCl. The soluble portion amounted to 49·24 per cent of the whole. As the amount of nepheline and analcite was calculated to be jointly 48·3 per cent, and as a very small

amount of aegirine went into solution, the figures given in the table may be regarded as closely approximating to the truth. Sodalite is neglected in the calculation, as the Cl determination is thought to be much too high, and none was seen in the sections. II*a* and *b* are Brögger's calculations of the Hedrum tinguaite (op. cit. 115, 191). As far as pyroxene and orthoclase go the two correspond very well, but in the Massachusetts rock analcite largely replaces the albite and nepheline present in the other. IV*a* is the calculated composition of the Foia tinguaite (op. cit. 259).

	I*a*.	II*a*.	III*a*.	IV*a*.
Aegirine	10·2	15·	---- }	14·
Pyroxene	3·3	--	15·1 }	
Orthoclase	17·3	17·	20·3	26·
Albite	20·9	36·	29·8	19·
Nepheline	10·9	31·	29·9	21·
Analcite	37·4	--	----	--
Sodalite	----	--	----	18·
Accessories	----	1·	4·8	--

The occurrence of analcite in tinguaite is by no means new, Rosenbusch having noted it in our rock, Ramsay and Hackmann* in that of Umptek (No. VI), and Wolff and Tarr† in that of the Crazy Mountains (No. VII). In a section of the Hot Springs Tinguaite No. V (kindly given me by Prof. Pirsson) the groundmass is seen to be sprinkled with clear, isotropic patches, which may be nepheline cut basally or else analcite, the grain being too fine to show cleavage. The probabilities are that they are analcite, as the appearance of the section is too fresh to admit our attributing much of the 5·44 per cent H_2O to decomposition. It is a common constituent of the closely analogous phonolites of Cripple Creek described by Cross.‡ The authors of the first two papers, together with Rosenbusch, regard the analcite as pseudomorphous after leucite or some other mineral. Cross regards it as primary, when discussing his phonolites. The possibility of the primary character of analcite in certain rocks has been upheld by Lindgren§ and Iddings,‖ and in a recent extremely suggestive paper Pirsson¶ has conclusively shown that what has been thought to be glassy base in the monchiquites is in reality analcite, and has greatly strengthened the arguments in favor of the occurrence of primary analcite in other rocks. In the present case

* Ramsay and Hackmann, Fennia 11, No. 2, 157, 1894.
† Wolff and Tarr, Bull Mus. Comp. Zoöl., xvi, 230, 1893.
‡ Cross, 16 Ann. Rep. U. S G. S., Pt. II, 32, 36, 1895.
§ W. Lindgren, Proc. Cal. Acad. Sci (2), iii, July, 1890.
‖ Iddings, Jour. Geol., i, 638, 1893.
¶ Pirsson, Jour. Geol., iv, 679, 1896.

the texture and composition of the tinguaite render the separation of the analcite for analysis a practical impossibility, so that its presence cannot be definitely proved as in the case of Lindgren's analcite-basalts and the monchiquites. But the chemical analysis of the rock, and the physical properties previously mentioned, leave little doubt on this point. In support of its primary character we must fall back upon the freshness of the rock and the general arguments advanced by Pirsson and Lindgren.

It would seem necessary therefore to recognize the occurrence of analcite as a constituent of the tinguaites by the use of the name *analcite-tinguaite*, and to this subgroup the tinguaites of Manchester, Umptek, Crazy Mountains and possibly Hot Springs and other localities belong.

Locust, N. J., June 29, 1898.

ART. XVIII.—*Note on the Occurrence of Native Lead with Roeblingite, Native Copper, and other minerals at Franklin Furnace, N. J.;* by WARREN M. FOOTE.

MINING done some months ago in the Parker shaft, North Mine Hill, Franklin Furnace, N. J., at a depth of 800 feet, yielded along with the usual ores occasional traces of native copper.* With it occur a number of minerals including roeblingite;† this species is found rarely in white masses in a grey porcellanous substance; again, in balls or radial aggregations of minute prismatic crystals, their terminations presenting a velvet surface; also in brown and reddish masses.

From different sources were secured specimens coming from this vein. In examining them with a lens, I noted a dull and discolored substance occurring in thin flakes. Its lead color and high luster on a fresh surface, with its unusual sectility, softness and malleability, at once suggested native lead. A small piece was tested on charcoal. In the oxidizing flame it easily volatilized, and a yellow coating was deposited, which disappeared under the reducing flame. A grain of the metal was quickly dissolved in hot dilute nitric acid.

Four specimens were secured, and further search and inquiry proved the metal to have occurred most sparingly. In one the lead is found in exceedingly thin scales or films, filling the crevices of the earthy porcellanous mineral, which broke so that flat surfaces of the lead were exposed; with it is inti-

* J. E. Wolff, Proc. of the Am. Acad. of Arts and Sciences, vol. xxxiii, No. 23.
† This Jour., vol. iii, p. 413, S. L. Penfield.

mately associated similar scales of native copper. Another specimen, consisting of garnet and brownish roeblingite, exhibits two irregular masses of lead 1 to 2 mm. diameter; also scales of lead and a globular mass of the metal with a white crystalline coating, and intermingled with a mass of copper. With it occur minute tabular crystals of an undetermined mineral. A mass of axinite, willemite, garnet, phlogopite and a new brick-red, lead-iron-calcium silicate,* shows a vein of copper crystals. They are irregularly distorted dodecahedrons, and pass into rough bands, where traces of lead are discernible. The fourth specimen is a compact form of pale yellow resinous polyadelphite, showing minute nuggets and films of lead and copper. No traces of lead crystals were observed.

The finding of roeblingite and another lead silicate in this vein with native lead, presents an analogy to that recorded at the prominent locality of lead, Långban, Sweden. Here it is found with a mineral containing lead silicate, ganomalite. This double occurrence of the metal with its silicate perhaps offers a field for investigation.

Besides adding one more species to the list of a locality famous for the number and variety of its minerals, the discovery is of interest because of the doubt surrounding the reported finds of lead outside of Sweden.

July 13, 1898.

* S. L. Penfield and H. W. Foote, this Jour., vol. v, p. 289.

ART. XIX.—*On the Position of Helium, Argon and Krypton in the Scheme of Elements;** by WILLIAM CROOKES, F.R.S.

IT has been found difficult to give the elements argon and helium (and I think the same difficulty will exist in respect to the gas krypton) their proper place in the scheme of arrangement of the elements which we owe to the ingenuity and scientific acumen of Newlands, Mendeléef and others. Some years ago, carrying a little further Professor Emerson Reynold's idea of representing the scheme of elements by a zigzag line, I thought of projecting a scheme in three dimensional space, and exhibited at one of the meetings of the Chemical Society† a model illustrating my views. Since that time, I have rearranged the positions then assigned to some of the less known elements in accordance with later atomic weight determinations, and thereby made the curve more symmetrical.

Many of the elemental facts can be well explained by supposing the space projection of the scheme of elements to be a spiral. This curve is, however, inadmissible, inasmuch as the curve has to pass through a point neutral as to electricity and chemical energy twice in each cycle. We must therefore adopt some other figure. A figure-of-eight will foreshorten into a zigzag as well as a spiral, and it fulfils every condition of the problem. Such a figure will result from three very simple simultaneous motions. First, an oscillation to and fro (suppose east and west); secondly, an oscillation at right angles to the former (suppose north and south), and thirdly, a motion at right angles to these two (suppose downwards), which, in its simplest form, would be with unvarying velocity.

I take any arbitrary and convenient figure-of-eight, without reference to its exact nature; I divide each of the loops into eight equal parts, and then drop from these points ordinates corresponding to the atomic weights of the first cycle of elements. I have here a model representing this figure projected in space; in it the elements are supposed to follow one another at equal distances along the figure-of-eight spiral, a gap of one division being left at the point of crossing. The vertical height is divided into 240 equal parts on which the atomic weights are plotted, from H=1 to Ur=239·59. Each black disc represents an element, and is accurately on a level with its atomic weight on the vertical scale.

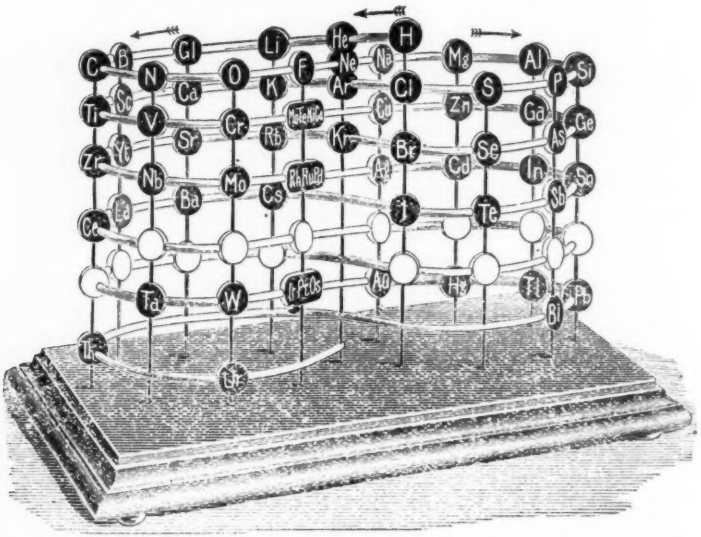
* Read before the Royal Society, June 9; from an advance proof sent by the author.

† Presidential Address to the Chemical Society, March 28, 1888.

The accompanying figure, photographed from the solid model, illustrates the proposed arrangement. The elements falling one under the other along each of the vertical ordinates, are

H	He	Li	Gl	B	C	N	O	F	Na	Mg	Al	Si	P	S
Cl	Ar	K	Ca	Sc	Ti	V	Cr	Mn·Fe·Ni·Co	Cu	Zn	Ga	Ge	As	Se
Br	Kr	Rb	Sr	Yt	Zr	Nb	Mo	Rh·Ru·Pd	Ag	Cd	In	Sn	Sb	Te
I	—	Cs	Ba	La	Ce	( )	( )	( )	( )	( )	( )	( )	( )	( )
( )	—	( )	( )	( )	( )	Ta	W	Ir·Pt·Os	Au	Hg	Tl	Pb	Bi	—
—	—	—	—	—	Th	—	Ur	—	—	—	—	—	—	—

The bracketed spaces between cerium and tantalum are probably occupied by elements of the didymium and erbium groups. Their chemical properties are not known with sufficient accuracy to enable their positions to be well defined. They all give colored absorption spectra and have atomic weights between these limits. Positions marked by a dash (—) are waiting for future discoverers to fill up.



Let me suppose that at the birth of the elements, as we now know them, the action of the *vis generatrix* might be diagrammatically represented by a journey to and fro in cycles along a figure-of-eight path, while simultaneously time is flowing on, and some circumstance by which the element-forming cause is conditioned (e. g., temperature) is declining; (variations which I have endeavored to represent by the downward slope.) The result of the first cycle may be represented in the diagram by

supposing that the unknown formative cause has scattered along its journey the groupings now called hydrogen, lithium, glucinum, boron, carbon, nitrogen, oxygen, fluorine, sodium, magnesium, aluminium, silicon, phosphorus, sulphur and chlorine. But the swing of the pendulum is not arrested at the end of the first round. It still proceeds on its journey, and had the conditions remained constant, the next elementary grouping generated would again be lithium, and the original cycle would eternally reappear, producing again and again the same fourteen elements. But the conditions are not quite the same. Those represented by the two mutually rectangular horizontal components of the motion (say chemical and electrical energy) are not materially modified; that to which the vertical component corresponds has lessened, and so, instead of lithium being repeated by lithium, the groupings which form the commencement of the second cycle are not lithium, but its lineal descendant, potassium.

It is seen that each coil of the lemniscate track crosses the neutral line at lower and lower points. This line is neutral as to electricity, and neutral as to chemical action. Electro-positive elements are generated on the northerly or retreating half of the swing, and electro-negative elements on the southerly or approaching half. Chemical atomicity is governed by distance from the central point of neutrality; monatomic elements being one remove from it, diatomic elements two removes, and so on. Paramagnetic elements congregate to the left of the neutral line, and diamagnetic elements to the right. With few exceptions, all the most metallic elements lie on the north.

Till recently chemists knew no element which had not more or less marked chemical properties, but now by the researches of Lord Rayleigh and Professor Ramsay, we are brought face to face with a group of bodies with apparently no chemical properties, forming an exception to the other chemical elements. I venture to suggest that these elements, helium, argon, and krypton in this scheme naturally fall into their places as they stand on the neutral line. Helium, with an atomic weight of 4, fits into the neutral position between hydrogen and lithium. Argon, with an atomic weight of about 40, as naturally falls into the neutral position between chlorine and potassium. While krypton with an atomic weight of about 80, will find a place between bromine and rubidium.

See how well the analogous elements follow one another in order: C, Ti, and Zr; N and V; Gl, Ca, Sr, and Ba; Li, K, Rb, and Cs; Cl, Br, and I; S, Se, and Te; Mg, Zn, Cd, and Hg; P, As, Sb, and Bi; Al, Ga, In, and Tl. The symmetry of these series shows that we are on the right track. It also shows how many missing elements are waiting for discovery,

and it would not now be impossible to emulate the brilliant feat of Mendeléef in the celebrated cases of Eka-silicon and Eka-aluminium. Along the neutral line alone are places for many more bodies, which will probably increase in density and atomic weight until we come to inert bodies in the solid form.

Four groups are seen under one another, each consisting of closely allied elements which Professor Mendeléef has relegated to his 8th family. They congregate around the atomic weight 57, manganese, iron, nickel and cobalt; round the atomic weight 103, ruthenium, rhodium, and palladium, while lower down round atomic weight 195 are congregated osmium, iridium and platinum. These groups are interperiodic because their atomic weights exclude them from the small periods into which the other elements fall; and because their chemical relations with some members of the neighboring groups show that they are interperiodic in the sense of being formed in transition stages.

Note, June 22d, 1898. Since the above was written Professor Ramsay and Mr. Travers have discovered two other inert gases accompanying argon in the atmosphere. These are called Neon and Metargon. From data supplied me by Professor Ramsay, it is probable that Neon has an atomic weight of about 22, which would bring it into the neutral position between fluorine and sodium. Metargon is said to have an atomic weight of about 40; if so, it shares the third neutral position with argon. I have marked the positions of these new elements on the diagram.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a New Constituent of Atmospheric Air.*—On the 9th of June, Ramsay and Travers read a preliminary note before the Royal Society on the discovery of a new gas in the atmosphere. For this purpose about 750^{cc} of liquid air were allowed to evaporate slowly until only 10^{cc} remained. The gas from this was collected in a holder, and the oxygen was removed by copper and the nitrogen by a mixture of pure lime and magnesium dust. After sparking the residue in presence of oxygen and caustic soda 26·2^{cc} of a gas remained, which showed feebly the spectrum of argon and in addition an entirely new spectrum. Though not completely separated from argon, the new spectrum was characterized by two very brilliant lines, one of which was closely coincident with D_3 and which rivaled it in brilliancy. Measurements with a grating of 14438 lines to the inch gave the following

values, all four lines being simultaneously visible: D_1 5895·0, D_2 5889·0, D_3 5875·9, D_4 5866·65; +1·7 to correct to vacuum. A green line was also seen comparable in intensity with the green helium line, of wave-length 5566·3, and a somewhat weaker green line 5557·3. Comparing simultaneously the spectrum of the new gas with that of argon, both in the spectrum of the first order, the wave-lengths of the lines of the new gas found in the violet were 4317, 4387, 4461, 4671; in the blue 4736, 4807, 4830, 4834, 4909; in the green 5557·3, 5566·3; in the yellow 5829, 5866·5; and in the orange 6011. By weighing the gas in a bulb of 32·321^{cc} capacity under a pressure of 521·85^{mm} and at 15·95°, its mass was found to be 0·04213 gram; which corresponds to a density of 22·47, that of oxygen being taken as 16. After sparking four hours with oxygen in presence of soda, the mass obtained was 0·04228, at 523·7^{mm} and 16·45°. This corresponds to a density of 22·51. The wave-length of sound in the gas was found to be 29·87, 30·13 in two cases, that in air being 34·17, 34·30, 34·57. Now since the square of the wave-length in air × its density: the square of the wave-length in the gas × its density:: the ratio of the two specific heats of air: this ratio for the gas, we have

$$(34{\cdot}33)^2 \times 14{\cdot}479 : (30)^2 \times 22{\cdot}47 :: 1{\cdot}408 : 1{\cdot}666.$$

From which it appears that the new gas, like argon and helium, is monatomic and therefore elementary. Whence the authors conclude that the atmosphere contains a new gas heavier than argon, and less volatile than nitrogen, oxygen or argon. It has a characteristic spectrum and the ratio of its specific heats leads to the inference that it is monatomic and hence an element. In case this conclusion is sustained they propose for it the name "*krypton*" or "concealed," with the symbol Kr. As to its position in the periodic arrangement, the authors conjecture that it may turn out to have a density of 40 with an atomic mass of 80, and so may belong to the helium series.—*Nature*, lviii, 127, June, 1898. G. F. B.

2. *On the Direct Elimination of Carbon Monoxide and on its Reaction with Water.*—It has been observed that when heated, certain organic compounds decompose and yield carbon monoxide directly and not as a reduction product of carbon dioxide. This reaction has been examined by Engler and Grimm. Thus formic acid at 150°–160° gives gaseous products which contain 98·8 per cent carbon monoxide and 1·2 per cent carbon dioxide. Ethyl formate, which decomposes at 300°, yields a mixture composed of carbon monoxide 18·2, carbon dioxide 29·5, ethylene 7·2 and hydrogen 45·1 per cent. At the same temperature amyl formate decomposes similarly, but yields amylene in place of ethylene. Ethyl oxalate gives at 200° carbon monoxide 48·4, carbon dioxide 43·8 and 7·8 per cent of olefines. At 280° benzoin gives a gas which contains 92 per cent of carbon dioxide and 8 of the monoxide; an oily residue being also produced containing di-

phenylmethane, desoxybenzoin, benzil and as a decomposition-product, benzaldehyde. No gas is yielded by benzoylacetone at 300°. Carbon monoxide, pure and carefully freed from oxygen, does not react at 250° with water vapor, but does react at 300°, giving carbon dioxide. So that it seems probable that the formation of carbon dioxide in the various decompositions above mentioned is due to a secondary reaction between carbon monoxide, the primary product, and the vapor of water.—*Ber. Berl. Chem. Ges.*, xxx, 2921–2926, December, 1897. G. F. B.

3. *On Osmotic Pressure and Electrolytic Dissociation.*—The conclusion had been reached by TRAUBE some time ago that the contraction which takes place on the solution of a substance in water is proportional to the concentration of the solution, and is almost independent of the nature of the dissolved substance. This contraction has a value of about 13·5^{cc} for every dissolved gram-molecule of a non-electrolyte or for every dissolved gram-ion of an electrolyte. This contraction in aqueous solutions is conjectured to be due to the strong attraction between the solvent and the dissolved substance; and this suggests the hypothesis of a union (though a changing one) between the water and the substance which is dissolved. The number of water particles with which a given molecule of a substance in dilute solution combines, is equal for all non-electrolytes, and for dissolved electrolytes increases proportionally to the number of ions. From this fact, Van't Hoff's conclusion, that the osmotic pressure of a solution is equal to the pressure which the dissolved substance in the form of a gas would exert at that temperature, may be deduced. Use is made however, in this deduction, of the hypothesis that a molecule of any non-electrolyte in any dilute solution at any given moment is in union with only one particle of the solvent. The author shows that his views and those of Poynting accord better with observed facts than do the ordinary views of osmotic pressure. The following facts find in them their explanation: (1) Molecular weights vary, as determined in different solvents, (2) colloidal substances have an osmotic pressure equal to zero, or nearly so, (3) the course of any given reaction depends largely upon the nature of the solvent employed, as shown by Menschutkin, and (4) the fact of sugar inversion and analogous processes. Arrhenius's hypothesis of electrolytic dissociation is considered entirely superfluous. The view of the author is that in dilute solutions, of sodium chloride for example, one molecule of the salt is joined to two of water; while in concentrated solutions they are united one to one.—*Ber. Berl. Chem. Ges.*, xxxi, 154–159, February, 1898. G. F. B.

4. *On Fusion in the Electric Furnace.*—The effect produced by heating lime mixed with varying proportions of silica in the electric furnace has been investigated by ODDO. He used an alternating current of 120 amperes under a pressure of 40 volts. When granular lime alone was employed, which as is well known readily combines with water, a mass of crystalline scales was obtained which did not slake until after two or three days con-

tact with water. When a mixture of lime and silica in molecular proportions was heated in the electric furnace a crystalline mass of calcium metasilicate $CaSiO_3$ was obtained, which yielded gelatinous silica with hydrogen chloride and did not set when ground and mixed with water, either alone or mixed with lime. A mixture in the proportion of $(CaO)_2$: SiO_2 is more refractory in the furnace, though it yields ultimately a compact crystalline mass of calcium orthosilicate Ca_2SiO_4, which placed in a dessicator, spontaneously disintegrates to a white amorphous powder. The salt itself gives gelatinous silica with hydrogen chloride and does not set with lime. When a mixture in the proportion of $(CaO)_2$: SiO_2 is thus heated, a crystalline mass results which has the approximate composition $Ca_2SiO_4 . CaO$, and which disintegrates spontaneously like the orthosilicate, the result being a mixture of lime with the orthosilicate. This material also does not set with lime, and gives gelatinous silica with hydrogen chloride. Similar results are obtained when the CaO is to the SiO_4 as 6 is to 1. It appears therefore that whenever silica is heated with excess of lime combinations occurs only in the proportion needed to form orthosilicate.—*Real. Accad. Linc.* V., v, 361; *J. Ch. Soc.*, lxxiv, 219, May, 1898. G. F. B.

5. *On Ammonium Peroxide.*—In investigating peruranic acid, MELIKOFF and PISSARJEWSKI concluded that its salts were compounds of peruranic acid with metallic peroxides; and hence that the hydrogen ammonium salt must contain ammonium peroxide. When a concentrated ethereal solution of hydrogen peroxide cooled to $-20°$ is made to act on an ethereal solution of ammonia equally cooled, a heavy viscous liquid separates, having a faint odor of ammonia, and being strongly alkaline. With potassium hydroxide it yields ammonia and potassium peroxide. It irritates the skin, producing white stains. When the ethereal solution is cooled in solid carbon dioxide, acicular leaflets separate having the composition $(NH_4)_2O_2 . (H_2O_2)_2 . (H_2O)_{10}$. A better yield is obtained when the ethereal mixture is placed in a freezing mixture of snow and calcium chloride. Crystals then separate having the composition $(NH_4)_2O_2 . H_2O_2 . H_2O$. They are unstable and deliquesce at the ordinary temperature, first yielding ammonia and hydrogen peroxide, and then evolving oxygen with a little ammonium nitrite. The crystals readily abstract carbon dioxide from the air. They dissolve in alcohol, less readily at $-30°$. With peruranic acid, they give $(NH_4)_2O_2 . (UO_4)_2$.—*Ber. Berl. Chem. Ges.*, xxx, 3144, January, 1898; xxxi, 152–154, February 1898. G. F. B.

6. *On the Molecular Masses of Inorganic Salts.*—Aided by four of his students, WERNER has determined the molecular masses of a number of inorganic salts by the rising of the boiling point of an organic solvent, selected so that no dissociation would be expected. Many nitrogen and sulphur compounds were found suitable as solvents, piperidine, pyridine, benzonitrile, methyl, sulphide and ethyl sulphide being actually employed, the inorganic salts experimented with being for the most part the halogen

compounds of silver, cadmium, tin, copper, mercury, lead, iron, zinc, cobalt, nickel and aluminum. Some of these salts were found to form additive compounds with piperidine, and in a few cases with the other solvents, as lead nitrate with pyridine, cuprous chloride and cadmium iodide with methyl sulphide and mercuric iodide with ethyl sulphide. By means of solutions of anthracene and diphenylamine, the molecular constant was obtained for each solvent, as follows: methyl sulphide 18·5, ethyl sulphide 32·3, pyridine 30·07, piperidine 28·4, benzonitrile 36·55. As a result most of the salts examined gave results which agreed with the normal molecular mass. Thus aluminum chloride gave figures agreeing with $AlCl_3$, the results being analogous for $FeCl_3$. Cobaltous chloride and bromide, stannous chloride and bromide, and lead nitrate are all monomolecular; i. e., contain bivalent metallic atoms. In the case of the cuprous salts however, anomalous results were obtained. Cuprous bromide in ethyl sulphide, for example, gave results corresponding to a molecular mass of 226, while in pyridine and in methyl sulphide, the value obtained corresponded with the molecular mass 140. Cuprous chloride gave in all solvents an elevation corresponding to 120 and cuprous cyanide one corresponding to the formula $Cu_2(CN)_2$. Hence the normal cuprous molecules are represented by the formula CuCl, etc. sometimes partially associated to Cu_2Cl_2. Since this result may also be explained by dissociation of the more complex molecules, conductivity determinations were made, the results of which indicated the absence of metallic ions. The silver haloids showed a similar tendency to polymerize, giving double and even treble molecules; confirming the author's views of the cuprous salts.—*Zeitschr. Anorg. Chem.*, xv, 1–41, May, 1897.

G. F. B.

7. *On Sodium Carbide.*—The properties of sodium carbide have been further studied by MATIGNON. It is a white solid of density 1·575 grams at 15°, insoluble in all solvents. Though endothermic it is not exploded by a shock or by friction. At ordinary temperatures, it is unacted on by air or oxygen if dry, but when heated gently it becomes incandescent and is converted into carbonate. In chlorine it burns evolving carbon; iodine converts it into C_2I_4, fusing at 185°. Water decomposes it violently, setting free carbon: but added very gradually converts it into acetylene-sodium hydroxide. Sodium carbide burns in hydrogen chloride, producing sodium chloride and evolving hydrogen and carbon. But if suspended in ether, it is completely converted into acetylene and sodium chloride. It becomes incandescent in CO_2 or SO_2, liberating carbon. Carbon monoxide does not act on it below 250°, nor hydrogen sulphide below 150°. Nitrous and nitric oxides attack it, the former at 270°, the latter at 150°, with incandescence, yielding carbon and sodium carbonate. Mixtures with oxidizing agents are very sensitive to shock. Alkyl iodides and bromides act on it at 180°, yielding symmetrical acetylenes RC ⋮ CR. It is a much more active salt than calcium carbide, and its reactions are almost always violent.—*C. R.*, cxxv, 1033–1035, December, 1897.

G. F. B.

II. Geology and Mineralogy.

1. *Cycad Horizons in the Rocky Mountain Region;* by O. C. Marsh.—After the article on the Jurassic Formation in this number of the Journal (pp. 105–115) was in print, I received some information about Cycad horizons in Wyoming, that bore directly on the question I discussed near the end of my paper. This information was of so much interest that I added a foot-note on p. 115, to place on record the important discovery by W. H. Reed, of two new Cycad localities in the Jurassic of Wyoming, both much farther west, and quite distinct from those already known around the Black Hills. One is in the Freeze Out Hills of Carbon County, and the other near the Wind River range.

Mr. Reed has since sent me a more complete account of the first of these localities, with a sketch showing the section of the strata where the Cycads were found, and also measurements of the successive strata exposed, from the Trias up to the so-called Dakota sandstone, that caps the bluff at that point. The marine Baptanodon beds here show a thickness of thirty-five feet. Above these is a series of fresh-water sandstones and shales, sixty-six feet in thickness, which in places contain remains of Laosaurus, a typical Jurassic Dinosaur. Immediately above these the Cycads occur in a narrow layer of white sandstone, and with them are various fragments of bones. Next above are fifty-five feet of strata containing vertebrate fossils, apparently indicating the Atlantosaurus beds. Above these are thirty feet of barren clays, and over all is the sandstone regarded as Dakota.

Mr. Reed has also sent me specimens of the Cycads found at this locality. As he has had an experience of twenty years or more on the Jurassic of the West, and is otherwise admirably qualified to judge of such horizons, his opinion is entitled to great weight, and should settle the question for this locality.

Mr. H. F. Wells, who has carefully explored the Black Hills Cycad horizon, and sent to the Yale Museum over one hundred specimens of these fossils, has also, at my request, sent me a sketch of a section near Blackhawk on the eastern rim of the Hills, a region which I have myself examined, although not recently. This section indicates that the Cycad horizon there is also in the Jurassic, and not in the Dakota, and this is borne out by other localities in the same vicinity.

Prof. L. F. Ward has published sections examined by him on the southwestern border of the Black Hills in 1893. He found no Cycads actually in place, but decided that the horizon in which they occur is Cretaceous.* I have recently placed in his hands for description all the western Cycads in the Yale Museum. Our views, however, do not at present coincide as to the age of the strata containing them, but the new facts which are now being brought to light will, I trust, soon place this matter beyond reasonable doubt.

Yale University, July 18, 1898.

* Journal of Geology, Vol. II, p. 250, 1894.

2. *Calamaria of the Dresden Museum.*—Professor H. B. GEINITZ, at the close of fifty-one years of active service as Director of the Dresden Museum, has contributed* a valuable revision of fossil Calamaria, adding some new forms, and perfecting the lists already published, by reconsideration of the nomenclature and reference to the bibliographical references up to the date of publishing. The report includes three *Archæocalamites* from the Culm. From the productive Coal Measures are reported 8 species of *Calamites*, 3 of *Calamitina*, 5 of *Asterophyllites*, 2 *Annularia*, 8 *Sphenophyllum*.

The Rothliegendes or Dyas furnishes eight representatives of *Calamodendron* which the author distributes in the genera *Calamites*, *Asterophyllites*, *Annularia* and *Sphenophyllum*.

H. S. W.

3. *Fossil Cephalopoda of the British Museum.*—Mr. G. C. CRICK, of the Geological Department, has prepared, and the British Museum trustees published, a complete list of the types and figured specimens of Fossil Cephalopoda in the Museum.† Each specimen is entered under the name given it when first figured or described, and additional reference is made to names subsequently applied. The entries are made in alphabetical order of genera. The Index is made alphabetical for species.

H. S. W.

4. *Two new fossils from Canada.*—Prof. J. F. WHITEAVES describes, in the Canadian Record of Science for October, 1897, two interesting fossils. *Actinosepia Canadensis*‡ is represented by a sepiostaire closely resembling that of the modern Sepia, but presenting generic differences from the Montana or Pierre-Fox Hills formation, at South Saskatchewan, opposite the mouth of Swift Current creek. The second§ is a tooth allied to *Holoptychius*, from the Upper Arisaig Series at McDonald's Brook, near Arisaig, N. S., supposed to be of the age of the Lower Helderberg, of the New York series. The specimen is provisionally referred to the genus *Dendrodus*, under the name *Dendrodus Arisaigensis*.

H. S. W.

5. *Brief notices of some recently described minerals.*—MIERSITE is the name given by L. J. Spencer to a new form of silver iodide crystallizing in the isometric system. It is thus dimorphous with the well-known iodyrite which belongs to the hemimorphic group of the hexagonal system. Miersite has been observed in cubic crystals, showing faces of one or both of the tetrahedrons. It

* Die Calamarien der Steinkohlenformation und des Rothliegenden im Dresdener Museum. Beiträge zur Systematik, von H. B. Geinitz. Mittheilungen aus dem König. Min.-Geol. u. prähistorischen Museum in Dresden, vol. xiv, pp. 1–28, taf. I, 1898.

† List of the types and figured specimens of Fossil Cephalopoda in the British Museum (Natural History); by C. G. Crick;, pp. 1–103. London, 1898.

‡ On some remains of a sepia-like cuttle fish from the Cretaceous rocks of the South Saskatchewan. Can. Rec. Sci. (October, 1897), pp. 459–461, pl. II.

§ Note on a first tooth from the Upper Arisaig Series of Nova Scotia; by J. F. Whiteaves. Can. Rec. Sci. (October, 1897), pp. 461–2.

has perfect dodecahedral cleavage and a pale or bright yellow color with adamantine luster. The locality is the Broken Hill silver mines of New South Wales. It is named after Prof. Henry A. Miers of Oxford.—*Nature*, April 14.

KALGOORLITE is a telluride of gold, silver and mercury described by E. F. Pittman from the telluride deposits of Kalgoorlie, West Australia. It occurs in massive form with subconchoidal fracture and iron-black color; specific gravity 8·791. An analysis by J. C. H. Mingaye gave the following results:

Te	S	Au	Ag	Hg	Cu
[37·26]	0·13	20·72	30 98	10·86	0·05 = 100

For this the formula $HgAu_2Ag_6Fe_6$ is calculated. Associated with kalgoorlite is a yellow telluride of gold (Te 56·65, Au 41·76, Ag 0·80) with sp. gravity = 9·377. This is referred to calaverite. —*Records of the Geol. Surv. of New South Wales*, vol. v.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association for the Advancement of Science.*—A pamphlet giving the preliminary announcements in regard to the Boston meeting of the Association has recently been issued. This meeting is to be held August 22d to 29th and will be a notable one in the history of the Association since it marks its fiftieth anniversary. The offices of the Association, the General Sessions, and the sessions of the different sections and of the affiliated societies will be accommodated in the buildings of the Massachusetts Institute of Technology, or in those of the Boston Society of Natural History and the Harvard University Medical School near by. The headquarters of the Association will be in the Rogers Building, while the hotel headquarters of the Council will be at the Copley Square Hotel, corner of Exeter street and Huntington avenue. The local Secretary, Prof. H. W. Tyler, of the Institute of Technology, has charge of matters referring to transportation, hotel accommodation, etc., and should be addressed on these subjects. The Permanent Secretary is Mr. L. O. Howard of the Department of Agriculture, Washington.

The first general session will be held at 10 A. M. on Monday, August 22d, when the meeting will be called to order by the retiring President, Professor Wolcott Gibbs, who will introduce the President-elect, Professor F. W. Putnam. Prof. Gibbs will deliver an address the same evening on "Some Points in Theoretical Chemistry." Wednesday, August 24, is appointed for an excursion to Salem, and Friday for one to Cambridge and Harvard University. Longer excursions to the White Mountains, Cape Cod, Plymouth, Wood's Holl, Newport, etc., will be begun on Monday, August 29.

2. *Harper's Scientific Memoir.*—It is announced by Messrs. Harper and Brothers that they will soon begin the publication of a series of translations and reprints of various scientific memoirs not readily accessible to the general student. Professor Joseph

S. Ames of Baltimore will act as general editor, and a list of twenty-two names is given of gentlemen who are to take an active part in the different departments. The series will be in general more or less similar to *Ostwald's Klassiker der exakten Wissenschaften* (Engelmann, Leipzig) often referred to in these pages; like this it will consist of thin octavo volumes, at once convenient for reference and inexpensive. Volumes I and II now in press, both edited by Professor Ames, are as follows :

I. Memoirs by Gay-Lussac, Joule, and Joule and Thomson on the Free Expansion of Gases.

II. Fraunhofer's Papers on Prismatic and Diffraction Spectra.

A number of other volumes are stated to be in course of preparation.

3. *Electro-Mechanical Series: Industrial Electricity.* Translated and adapted from the French of HENRY DE GRAFFIGNY and edited by A. G. ELLIOTT, B.Sc. 152 pp., 12mo. London and New York, 1898 (Whittaker & Co.)—In its original French form, this little volume and the others of the series have had much success, and it may fairly be assumed that they will have a similar reception among English readers. The present volume is preliminary and general in its character and the treatment of the different subjects is necessarily brief, since only one hundred and fifty pages are given to the whole from the nature of electricity to the telegraph. The other volumes in preparation which are soon to follow will take up separate topics in some detail.

4. *A Catalogue of Earthquakes on the Pacific Coast:* 1769 to 1897. (253 pp.) By EDWARD S. HOLDEN, LL.D. Smithsonian Miscellaneous Collections 1087. Washington, 1898.—This volume is a reprint and extension of the pamphlet on the same subject issued in 1887. It gives a complete account of the earthquake observations made at Mt. Hamilton during 1887–1897, together with an abstract of the large mass of information which has been collected from many sources regarding the Pacific coast earthquakes during this period. The Lick observatory was equipped with a set of Prof. Ewing's instruments in 1887 and in 1888 began its active work of registering earthquake shocks and in collecting material in regard to them.

5. *Ostwald's Klassiker der Exacten Wissenschaften.* Leipzig, 1898. (W. Engelmann.) The following volumes in this valuable series have recently been published.

Nr. 93. Drei Abhandlungen über Kartenprojection von Leonhard Euler. (1777.) 77 pp.

Nr. 94. Ueber das Verhältniss zwischen der chemischen Zusammensetzung und der Krystallform arseniksaurer und phosphorsaurer Salze. (Uebersetzt aus dem Swedischen.) Von Eilhard Mitscherlich. (1821.) 59 pp.

Nr. 95. Pflanzenphysiologische Abhandlungen. I. Bluten des Rebstockes. II. Bewegungen der Mimosa pudica. III. Elementarorganismen. IV. Brennhaare von Urtica. Von Ernst von Brücke. (1844–1862.) 86 pp.

Nr. 96. Sir Isaac Newton's Optik oder Abhandlung über Spiegelungen, Brechungen, Beugungen und Farben des Lichts. (1704.) I. Buch. 132 pp.